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Tasmania

DEPARTMENT OF MINES

GEOLOGICAL SURVEY BULLETIN

No. 15

The Stanley River Tin Field

BY

L. LAWRY WATERHOUSE, B.E., Assistant Government Geologist

Issued under the authority of

The Honourable J. E. OGDEN, Minister for Mines



Tasmania:

JOHN VAIL, GOVERNMENT PRINTER, HOBART

1914



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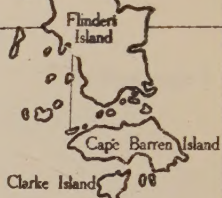
TASMANIA

SCALE OF MILES
5 0 5 10 15 20 25 30

RAILWAYS

Area dealt with in Bulletin No. 76

PLATE I



BANKS STRAIT



LOCALITY MAP

Photo Aligned by John Vail Government Printer Hobart Tasmania

W. W. Murray Waterhouse B.Sc.
Assistant Government Geologist
November 1913

The Stanley River Tinfield.

I.—INTRODUCTION.

(A.) GENERAL.

THE Stanley River Tinfield is one which has attracted considerable attention during the past. Like many other mining fields, it has been boomed; extravagant reports have caused indiscriminate pegging-out of sections, and when the first excitement has passed, interest in the field has waned considerably. At the present time, unfortunately, mining activity in the district is confined to two or three sections only, and very few sections are even being held. The field is certainly at a great disadvantage in that it is somewhat difficult of access.

An attempt is made in the following pages to try and ascertain the true cause of the present inactivity on the field, and to enquire whether there is a reasonable prospect of a revival of interest.

Not only is the general geology of the district described, but attention has been given to economic geology, and where possible, applications have been made to the mining properties. The properties which are working are described. As far as was possible all sections on which any work has been done were visited, and the results of such examination herein recorded. It is a matter for regret that in one instance information which would have greatly facilitated the writer's examination of the field was for some mysterious reason withheld. It should be borne in mind that the object of an officer's visit to a mining district is to *assist* those working on, or interested in, the district. In order that he may be able to do so, he must rely for a good deal of information on those who are able, through familiarity with the particular locality, to acquaint him with the past history and with details of workings, information which is of value to him in helping him to form a true opinion of the field, but which cannot be acquired without their help.

(B.) GEOGRAPHICAL POSITION.

The area constituting the Stanley River Tinfield proper extends from the Wilson River on the east to Mt. Livingstone on the west, and from the Upper Stanley southwards towards the Pieman River.

The Wilson and the Stanley are tributaries of the Pieman, flowing in a general southerly direction. Between them the Parson's Hood Range rises to nearly 3000 feet, and west of the Stanley again is the southern extremity of the Meredith Range, culminating in Mt. Livingstone, 2637 feet in height.

Thus it will be seen that the field is situated at the southern extremity of the Meredith Range. The area examined comprises about 50 square miles.

The central portion of the field is distant about 15 miles from Renison Bell, by pack-track, being north-west of the latter settlement, about 11 miles by air-line.

The track has been badly graded, and in consequence heavy packing charges place the companies on the field at a great disadvantage. All machinery has had to be either packed out on horseback, or hauled on sledges, at a cost of £13 to £14 per ton. As many stretches of the track are not corded, and as a rule the soil is a stiff clay 3 or 4 feet deep, the track becomes almost impassable in the winter when there is any traffic on it. The track crosses the Pieman River by a fine suspension bridge.

Zeehan is about 19 miles distant, by an older track, which connects with the Stanley River Field, constructed through open button-grass country all the way. This track was used until a few years ago, when the present one was constructed. The disadvantage of the route, which is now seldom used, lies in the fact that both the Stanley and Pieman Rivers have to be crossed by cages. No provision was made on this route for horses, which had to be taken round *via* Corinna and the Whyte River bridge, unless the river was low enough to ford.

Referring to other mineral fields, Mt. Bischoff is situated some 20 miles to the north-east, Rosebery about 16 miles south-east, Zeehan some 15 miles a little east of south, Heemskirk about the same distance a little west of south.

The nearest accessible point of the Emu Bay Railway is at Renison Bell, communication with which is maintained, as already mentioned, by pack-horses.

II.—PREVIOUS LITERATURE.

The first official examination of the Stanley River District was made early in 1895, by Mr. A. Montgomery, then Government Geologist.

His report was very brief, and is incorporated in a general "Report on the Progress of the Mineral Fields in the neighbourhood of Zeehan, viz., Mackintosh River, Mt. Black, Mt. Read, Mt. Dundas, Mt. Zeehan, Stanley River, and Mt. Heemskirk," issued from the Geological Surveyor's Office, Launceston, on 15th May, 1895.

At the time of Mr. Montgomery's report very little work had been done on the Stanley Reward sections. New's Creek had been worked for alluvial, and one or two quartz-tourmaline lodes were being prospected. The Mt. Lindsay ore-body had not then been discovered.

The only other official report on the field was a "Report on the Prospects of the Stanley River Tinfield," by Mr. G. A. Waller, Assistant Government Geologist, dated Zeehan, 25th January, 1904. Mr. Waller referred briefly to the general geology of the district, and dealt with the workings on the various sections. At the time of his visit little beyond prospecting had been done on the Reward sections, no plant being then erected. The prospecting being carried on was described. At this time the Mt. Lindsay ore-body was still undiscovered.

III. PHYSIOGRAPHY.

(1)—TOPOGRAPHY.

The topography of the district is interesting. The northern portion of the field is occupied by the southern extension of the rugged Meredith Range. This range, composed of granite, consists of a series of peaks well rounded in the characteristic fashion of weathered granite country. Although the range consists of so many broken peaks and minor ranges, viewed from a distance these are seen to be of approximately the same height, with here and there prominent peaks as Mt. Meredith and Mt. Cleveland. The rugged, broken nature of the range is due essentially to weathering agencies, which have been at work for a long period since the formation of the range.

The Stanley River, flowing south, has cut down through the southern portion of the range, the eastern culminating spur being Parson's Hood, and the western Mt. Livingstone.

Looking westward from either of these high peaks, one is immediately struck by the remarkably uniform nature of the country stretching away westwards to the coast. The inevitable conclusion one is forced to, is that this stretch of country represents an old peneplain. The country certainly is not absolutely level, in the strict sense of the term. It is dissected by various creeks and rivers forming part of the drainage system of the Pieman River, this river itself winding through the plain. Devoid of timber and scrub, except in the creek and river valleys, the gradual development of river valleys is splendidly shown. Although there are numerous low ridges, they are all of approximately the same height, giving the country a general level appearance when viewed from a distance, the minor inequalities being hidden. The surface is seen to have a general slope seawards, and it is interesting to determine the slope of this surface. Reference to the general map accompanying this report will show that the average height of the ridge which forms the furthest extension of the plain eastwards at this point is about 1600 feet above sea-level. The coast-line is about 16 miles distant, and I have been informed that the cliffs fringing the coast-line between the Heemskirk Range and the Pieman Heads are about 200 feet above sea-level on

the average: it was not possible on this occasion to check this figure. Assuming it to be so, the average slope seawards would be about 87 feet per mile.

Viewed from the summit of the Parson's Hood, the country to the south and east also appears generally level, and it would certainly seem that here, too, we have an extension of the same old peneplaned surface, extending to the base of the West Coast Range.

Looking in the direction of Mt. Bischoff, there is again a strikingly level sky-line for many miles.

Standing out above this general level are various peaks, as Mt. Donaldson to the west, the Heemskirk Range to the south-west, Mt. Zeehan to the south, and to the east Mt. Ramsay. Judged by the eye there is an apparent uniformity of level in several of these peaks, which suggests that they may represent remnants of a much older peneplain, and that they may, perhaps, have represented monadnocks standing out above the level of the later peneplaned surface.

Heights of various points, as determined by aneroid, and readings corrected, are shown on the accompanying plan.

It is seen that south of Parson's Hood and Mt. Livingstone, and also west of the latter, is a well-defined ridge from 1700 feet above sea-level south of Parson's Hood, to 1550 feet west of Livingstone. This ridge has been cut through by the Stanley River, and weathering agencies at the present time are still further dissecting it. But it is noticed that the drainage north of this range flows into the Stanley and Wilson rivers respectively. South, most of the streams flow into the Pieman itself.

Standing on any of the peaks to the south of Parson's Hood an interesting fact is noticed. The creek called Four-mile Creek is gradually cutting back further and further, and at the present time there is a strip of low-lying swampy ground forming the watershed between the Four-mile Creek (flowing into the Wilson River) and the Stanley River. It seems that we have here an example of impending river capture. As time goes on the creek will gradually cut back through this strip of low-lying ground, as its bed has a considerable fall, and capture the waters of the Stanley River, whose bed is very flat here. It is commonly reported that this creek represents the former bed of the Stanley River, and when viewing the locality from a point of vantage one does not wonder that this theory has been put forward. However, the

bed of the creek was examined carefully at several points, and in the wash is no trace of any of the granite facies of rocks, so abundantly represented in the main river. From two independent sources I learned that the wash in the low-lying ground referred to, and at various points along the creek, had been prospected for tin without success.

The fact of there being only this low strip of swampy ground forming the watershed between the Stanley and Wilson Rivers should be borne in mind when considering the advisability of a power scheme for the district, as the Stanley River could be dammed and the water diverted into the Four-mile Creek. The difference of level between this low point on the watershed and the Wilson River at the mouth of Four-mile Creek is 400 feet, according to aneroid readings.

In an area such as that under review, where various geological units are represented, we should expect to find the topography influenced by the geological units, but such is not the case to any great extent. The peak of the Parson's Hood Range on examination is found to consist of a plateau, over a mile in length, and $\frac{1}{4}$ to $\frac{1}{2}$ mile in width. The extreme south-eastern portion is the highest by perhaps 40 or 50 feet, but on the whole the summit is level. Yet here we have two distinct units represented, the northern portion being granite, and the southern slate.

Mt. Livingstone is schist, and yet just to the north are many peaks, of sensibly equal height, of granite. It should be noted here, however, that the shape of the mountain is characteristic. The planes of schistosity strike approximately north and south. As weathering naturally follows these planes, comparatively flat pieces are constantly breaking away, and this process long continued has distinctly modified the contour of the mountain, which is a long, narrow peak, with its axis north and south, sloping rather gradually away from the summit in these directions, but presenting a very steep face to the east. To the west, too, although there is a peak connected by a saddle with Mt. Livingstone, and of approximately equal height, the ground falls away rapidly. Showing out in decided contrast are the numerous rounded granite peaks to the north.

In the alluvial flat we know that in some portions the bottom is dolomite, in others granite: yet the two are approximately of equal altitude.

Away to the east of the area, in the valley of the Wilson River, are numerous low ridges of approximately the

same height, representing the old peneplaned surface dissected by the present river system; yet while many of these are soft Silurian slates and sandstones, with bands of limestone, others are gabbro and serpentine.

One respect in which the topography is distinctly influenced by the geology must not be overlooked, namely, the way in which certain of the rivers and creeks follow the contacts between different geological formations. We have the Wilson River flowing for some distance along the boundary of the serpentine with the Silurian slates and sandstones; the Harman River, marking the junction of serpentine with Pre-Silurian slates; New's Creek, marking the junction between Pre-Silurian slates and granite; Livingstone Creek, following the contact of granite and schist.

In conclusion, we may summarise the physiography of the region. The district is one which has undergone a long period of erosion, in which any sediments later than Devonian which may have existed have long since been removed. Irrespective of geological formations, a large portion of the surface has been worn down to such an extent that the grade of the rivers has become too flat to allow the detrital material to be carried to the sea. At this period the alluvial tin has been deposited. A subsequent elevation of the land surface has caused the streams to deepen their channels once more, and this cutting down of the river beds is proceeding at the present time. As evidenced by the traces of river-terraces at different points along the Stanley River, we may conclude that the elevation referred to has not been one simple movement, but rather a succession of such uplifts, sufficient time elapsing after each to allow the river to cut down to base-level.

The highest terrace noticed along the Stanley was about 100 feet (by aneroid reading) above the level of the river. Since the river had reached base-level, when this gravel was deposited, obviously there has been an uplift of at least 100 feet, to enable it to cut its bed to that level. If the river had now reached base-level again, we should interpret our field evidence to mean that the uplift had been exactly 100 feet; but as this is not the case, and the river is still eroding its channel, we are forced to the conclusion that the uplift must have been more than 100 feet, although how much more it is impossible to say.

Near the Pieman suspension-bridge, gravels were noted at about 320 feet above sea-level, or 150 feet above river-level, so that the uplift here has been over 150 feet.

(2)—METEOROLOGY.

The rainfall in the area under review is undoubtedly very heavy, but unfortunately no accurate figures are available to show the amount of moisture precipitated. A recording-station was established a few years ago on the field at the Stanley Reward, but owing to the very intermittent nature of the work on that section, systematic records have not been kept. This is a matter for regret. Within the past few months the rain-gauge has been removed and installed at Mt. Lindsay Mine, and it is to be hoped that the change will result in more regular records being kept.

The rainfall as recorded at surrounding stations is shown for several years in the accompanying tables.

For Zeehan and Mt. Read the annual distribution is shown, as the rainfall on the field probably approximates to a mean between these records. Mt. Read (recording-station) is the same height as Parson's Hood, in the centre of the district, and the country in between the two is comparatively low-lying. The two points are some 15 miles apart. Zeehan is nearly the same distance, but is about 2300 feet lower.

It will be seen that here, as elsewhere on the West Coast of Tasmania, the rainfall is considerable, and at no part of the year is it negligible. January and February are the driest months.

TABLE I.—Average Annual Rainfall in Inches.

Station.	Height of Station.	1906.	1907.	1908.	1909.	1910.	1911.	1912.	No. of Years.	Average Annual.
	feet.									
Magnet	...	...	98.26	80.42	87.29	96.66	81.67	77.75	...	...
Waratah	2000	117.24	108.65	86.52	94.62	97.17	88.43	87.20	26	85.40
Que...	...	...	...	...	...	...	71.93	78.33	...	...
Chester	...	...	...	...	...	...	...	75.87	...	...
Mt. Read	2867	144.04	123.20	114.50	116.18	112.91	130.09	147.71	10	108.48
Zeehan	535	...	101.40	96.78	108.30	116.14	95.97	90.52	19	98.04
Renison Bell	...	...	...	...	...	...	...	85.49	...	...

TABLE II.—Annual Distribution of Rainfall in Inches.

Month.	1906.		1907.		1908.		1909.		1910.		1911.		1912.		Average.	
	Mt. Read.	Zeehan.	Mt. Read.	Zeehan.	Mt. Read.	Zeehan.	Mt. Read.	Zeehan.	Mt. Read.	Zeehan.	Mt. Read.	Zeehan.	Mt. Read.	Zeehan.	Mt. Read.	Zeehan.
January .....	...	...	4.96	3.04	2.86	3.74	5.86	4.99	2.26	2.27	2.86	3.85	10.39	5.50	5.59	5.90
February .....	...	...	7.08	2.71	5.43	5.11	2.00	1.61	4.92	4.09	5.23	5.02	1.29	0.64	5.97	4.41
March .....	...	...	8.34	6.18	14.14	11.15	9.59	9.17	3.26	2.32	9.75	8.54	8.08	5.38	10.77	9.35
April .....	...	...	12.80	11.14	7.12	5.74	18.23	17.15	11.02	11.00	14.76	11.66	12.50	7.46	10.77	9.35
May .....	...	...	9.86	5.87	17.54	14.74	9.07	10.63	18.68	20.03	7.86	6.32	12.35	9.34	11.12	9.48
June .....	...	...	6.41	5.30	13.57	9.96	13.53	9.53	9.74	12.20	15.85	13.55	11.89	8.11	11.83	9.94
July .....	...	...	13.89	13.72	10.12	8.99	7.60	8.37	4.37	4.48	8.09	6.45	6.58	4.89	9.95	10.27
August .....	...	...	14.90	12.89	12.46	9.53	12.90	12.92	13.85	17.87	9.87	6.61	14.95	9.45	10.55	9.61
September .....	...	...	14.91	16.73	8.99	7.55	4.65	4.43	12.94	12.35	7.10	5.07	28.40	13.28	9.68	8.81
October	12.67	10.90	10.55	10.02	7.92	8.71	11.83	10.56	10.94	9.82	14.27	9.29	13.53	9.25	9.67	9.53
November	11.57	8.36	4.25	2.63	5.93	4.80	7.98	7.86	8.38	8.52	9.72	5.90	13.00	8.57	8.23	7.35
December	9.56	3.49	15.25	11.17	8.42	6.76	12.94	11.08	12.55	11.19	24.73	13.71	14.75	8.65	10.10	7.23

Hail is frequent during the winter months, and snow sometimes falls, though it seldom lies on the ground more than a few days, and hence does not provide a regular source of supply for the rivers. During the winter months when the weather clears, frosts are frequent, and at times severe. Probably the average annual rainfall on this field is about 100 inches.

The question of rainfall is extremely important to the mining companies on the field. The country is steep in the central portion of the field, and drains rapidly after rain falls. This is particularly noticeable in the granite country of the Meredith Range. Further to the south, where the soil is very clayey (that yielded by the slate series being a stiff yellow clay), the moisture is retained longer, hence the creeks heading from this area are more permanent than those fed from the granite.

The influence of the rainfall upon mining operations is strikingly shown in the case of the Stanley Reward Tin Mining Company, which draws its water for power and sluicing by means of a race from the Upper Stanley River. Yet after four or five consecutive days without rain the company is unable to work at full pressure owing to shortage of water. This might be improved slightly by an alteration of the race intake, but not to any great extent.

With a heavy rainfall such as we have here the tendency is to rapidly remove the surface soil, but fortunately the very moistness of the climate favours a very luxuriant growth of plant life, and the dense undergrowth assists very largely in arresting the removal of the surface soil. In passing it may be mentioned that this dense undergrowth, and what is in places impenetrable scrub, renders accurate field work difficult, and impossible in places.

(3)—ECONOMIC ASPECTS.

(a) *Prospecting and Exploitation.*

The watercourses here have played a somewhat important part in the prospecting of the district. Original prospecting of the district followed the Stanley River up from its junction with the Pieman River. For some miles the grade is very flat, the river here flowing through open button-grass country. Little success was met with in the lower portion of the river, but as the granite was approached tin became more abundant, and finally the alluvial flats now held by the Stanley Reward Tin Min-

ing Company were discovered. In its upper reaches, as one penetrates the gorge cut by the Stanley into the Meredith Range, the grade of the bed increases rapidly, and advantage is taken of this in the race cut by the Stanley Reward Company. The race is between 3 and 4 miles in length, and, as shown in the accompanying plan, winds round the base of the Parson's Hood, giving a pressure of about 300 feet.

The topography has enabled the tin ore shed from the surrounding granite and from the contained quartz-tourmaline veins to be concentrated in the flat which is now being worked. Not only in the Stanley River, but in the beds of tributary creeks has the tin ore been concentrated by natural agencies. Both Castle's Creek from the west, and New's from the east, have been worked, ground and box sluicing being generally employed. In the case of both these creeks it has been mainly the lower portions which have favoured the concentration of the tin, the creeks rising rapidly into the hills towards their sources. Tulloch Creek, rising in Parson's Hood and flowing southwards, cut through the large Mt. Lindsay ore-body, and as tin occurs *in situ* right on the surface outcrop of the latter, it might naturally be expected that some of the cassiterite would have been found along its bed. An examination, however, has shown that the gradient of the bed is very steep, and offers no encouragement for the lodgment of any quantity of detrital matter. It is not surprising, therefore, that very little alluvial tin has been discovered in this creek. However, at the spot where this creek enters the Four-mile Creek, a tributary of the Wilson River, there is an alluvial flat, apparently not of any great extent, which does not appear to have been prospected. It is possible that some of the cassiterite shed from the Mt. Lindsay ore-body may have found a lodgment under these more favourable conditions.

The fact of this creek being steeply graded is likely to be of benefit for power purposes.

The bed of the Stanley River itself, where the first tin of the district was discovered, is still occasionally worked by blind-stabbing in the dry weather when the river is low.

Prospecting up Castle's Creek for the source of the tin discovered there, a quartz-tourmaline lode was discovered, which will be referred to later, but little work has been done. Similarly, the little prospecting that has been done up New's Creek led to the discovery of one or two

other formations. Far less prospecting, however, has been done here than the alluvial tin warrants.

Referring to exploitation, the topography has favoured what little has been done in this respect.

The Mt. Lindsay Company has taken advantage of the uneven nature of the country and has opened up the ore-body by means of crosscuts and adits driven into the hill-side. Further work is necessary in this direction, and in particular, the need for a main low-level adit is great. This matter will be referred to later on.

On Section 3953-M a little driving was done to open up a quartz-tourmaline lode.

At Mt. Merton, the tin-bearing formation is being opened up by a crosscut drive, but this might with advantage have been driven somewhat lower down the hill, to give a rather greater quantity of backs.

On the whole, very little advantage has been taken of the topography of the district in exploitation.

Against the advantages of an area of broken country, cut up by gorges, must be borne in mind the disadvantages owing to difficulty of transport, which in this particular area are considerable.

(b) *Water-supply.*

The question of water-supply is one of vital importance on the field. The needs of the companies may be considered independently.

The Stanley Reward sections depend entirely on the rainfall for their water-supply. Water is brought from the Upper Stanley, where the race intake is situated. As the method of working employed here is sluicing and hydraulic elevating, it will at once be seen how vital the question of water-supply becomes. The uncertainty of the supply has indeed militated against the success of operations during the past. Even four or five days without rain causes a shortage in the supply, and if continued, either a partial or complete cessation of operations. The Upper Stanley flows through steep granite country, which rapidly drains after rain has ceased to fall. As far as the writer went up the river, no suitable site for a reservoir was noticed. In the rainy season there is a large volume of water coming down the river, and it is a matter for regret that the excess cannot be stored and used as required.

It has been suggested that water may be brought from the Harman River. The race-cutting involved would be

long, as it would be necessary to bring the water round the southern end of the Parson's Hood Range, and as will be seen from the topographical map, the spurs and valleys are numerous, and probably rather extensive fluming would be required. There is a large flat on the Harman River, which, when viewed from a distance, appears to offer many advantages for water-conservation. Even were the damming back of the water feasible here, the flat is too low to benefit the Stanley Reward. The exact level was not determined, but it is probably not more than 450 or 500 feet above sea-level. The level of the river where the Mt. Ramsay track crosses, 2 or 3 miles below this flat, is 345 feet above sea-level, as determined by corrected aneroid readings; and the river just above this point does not appear to rise very rapidly. Towards its head, the Harman River is small, and heading from granite country is liable to considerable fluctuation.

With reference to the Mt. Lindsay Mine, no use is being made at the present time of the water supply available, as exploitation work only is being carried on, and no milling. It is inevitable that a small plant shall be installed in the near future, when the question of the water-supply will be of extreme importance. Tulloch Creek, which cuts through the section, is of small size only, and probably not more than one sluiceway can be relied on, although there is considerably more in the wet seasons. The grade of the bed is steep. This creek would not provide more than sufficient dressing-water for a small mill. If a deep level adit be driven, this would provide a little more water, but not any considerable amount, as the Mt. Lindsay spur is well drained naturally.

In the Wilson River is an abundant supply all the year round.

At Mt. Merton the creek called Christmas Creek could be utilised for a small plant only. In the event of the formation warranting a larger plant, some other arrangement would have to be made. Possibly the Wilson River would be utilised, although this portion of the country, and more particularly that to the east was not examined in sufficient detail to warrant a definite opinion being expressed on this point. Although hilly, the valleys here are, on the whole, of even grade, and it is probable that long race-cutting will be necessary to obtain sufficient head for power. Pumping seems unavoidable.

(c) Power.

Advantage has been taken of the configuration of the country by the Stanley Reward Company, in utilising water from the Upper Stanley for sluicing and motive power.

As already mentioned, although the bed of the Stanley is comparatively level in the lower portion of its course, the upper portion of the river is steeply graded, and advantage was taken of this fact in the construction of the race. After between 3 or 4 miles of race, the water descends to the flat by a pipe column some 3000 feet in length, giving a pressure of about 300 feet. This pressure is utilised for elevating the wash by means of hydraulic elevators to the sluice-boxes. As is well known, elevators of this type have a low efficiency. Where water is abundant this question is not of paramount importance, but it becomes a serious question in this case, where the supply is variable. The wash was being elevated a distance of about 40 feet vertically in the previous position of the plant. The plant was being moved, and had not been re-erected at the completion of the writer's examination of the district.

Portion of the available water was being utilised to break down the ground by means of nozzles. A small portion of the available power was converted to electrical energy by means of a dynamo driven by a small Pelton wheel, and utilised for illuminating the plant and workings when night-shift was being worked.

At Mt. Lindsay Mine the question of power will have to be seriously considered very shortly. Tulloch Creek would not furnish power for any but a small mill; should such be installed it will probably be found necessary, in order to utilise the water available to best advantage, for both power and dressing, to have the mill below the power-station, using the dead water for dressing. No very suitable spot was noticed where the creek might be dammed, the slope of the range here being excessive for that purpose. This object was kept in mind also when traversing the summit of Parson's Hood. The summit, especially towards the southern end, is comparatively level, and could a site for a reservoir be located here, it would be of great value to the companies concerned. Conditions, however, did not appear very favourable, judging from the general examination made. There is, however, one creek just to the north of the extreme summit which merits further inspection. The creek-bed was not

followed, but from a cursory examination it appeared likely that a dam-site might be found a little lower down, which would store a considerable volume of water if a dam of moderate length and height were constructed. As will be seen from meteorological statistics given, at Mt. Read, with an altitude equal to that of the spot under consideration, the rainfall is considerable all the year round.

When a larger mill is being considered by the Mt. Lindsay Company, the Wilson River will probably be utilised. Ample water is available here for all purposes. The fall in the river for a few miles above its junction with the Harman River appears to be about 40 feet per mile. It is probable that a little further north the river-bed is graded more steeply. At the junction of the Harman River with the Wilson the level is about 1165 feet below the Mt. Lindsay Mine.

It may be found advisable to divert the water from the South-east Creek into Tulloch Creek, some distance below the Mt. Lindsay Mine. As determined by corrected aneroid readings, there is a difference of level between these two creeks on the Mt. Ramsay track of 140 feet.

In discussing the creeks suitable for power purposes, the Four-mile Creek should not be altogether overlooked. This creek carries a fair volume of water, and has a steeply-graded bed. Drawing most of its water from the drainage of clay soil, the supply is likely to be rather more constant than that of creeks draining granite country. The possibility of diverting the water of the Stanley River into this creek has already been referred to.⁽¹⁾

In examining this creek with a view to utilising it for power purposes the writer was much impressed with one possible method of obtaining abundant power, viz., by diverting the water of the Stanley River. The low swampy ground which forms the watershed between Wilson and Stanley Rivers at the head of the Four-mile Creek has already been referred to. The height of this swamp above the Stanley is not more than about 15 feet, according to aneroid readings. The point where the Four-mile Creek enters the Wilson is approximately 400 feet lower. So that, obviously, if the level of the Stanley River could be raised about 15 feet nearly 400 feet of head could be obtained from a race.

(1) *Vide* page 6.

IV.—GENERAL GEOLOGY.

The general geology of the district will be dealt with under separate headings and sub-headings.

First the igneous rocks will be taken, and various groups described—(i) Porphyroid, (ii) Basic, (iii) Intermediate, (iv) Acidic.

Then the sedimentaries and their modifications will be treated: (i) Pre-Cambrian schists, quartzites, and slates; (ii) Pre-Silurian slates, sandstones, and tuffs; (iii) Pre-Devonian dolomite; (iv) Silurian sandstones, slates, and limestones; (v) Pleistocene river gravels; (vi) Recent alluvial deposits.

Finally, the general sequence of events leading to the present geological structure will be described and summarised.

A.—IGNEOUS ROCKS.

(1)—*Porphyroid Group.*

At one or two points in the district, within the area occupied by the Pre-Silurian series of slates, sandstones, and tuffs, loose fragments of porphyroids were found. At no place were they located *in situ*, although careful search was made. The possibility of overlooking these rocks in a densely-timbered district, in which outcrops are comparatively few, and in which the old sedimentaries are so altered by contact-metamorphism as to themselves closely resemble igneous rocks, will at once be recognised. In several instances outcrops were noted and specimens collected of rocks which were believed on the field to be porphyroids, but a microscopical examination revealed the fact that they were contact metamorphic sedimentaries.

As the rocks have not been located *in situ* in this district, and as therefore no information is available from this field as to their relation to other rocks of the district, it seems quite unnecessary to deal with them in any detail here, particularly as they are being described in some detail at the time of writing by another officer of the Geological Survey, from a district where they are well developed,⁽²⁾ in addition to having been previously described.

(2) "The Jukes-Darwin Mining Field," by L. Hills.

Suffice to say here that they are now recognised as being igneous rocks, which have been shattered and rendered schistose, and in which partial recrystallisation of the constituent minerals has taken place, owing to the metamorphism they have undergone. It is recognised that some types are intrusive into the sedimentary rocks with which they are associated, while others are interbedded with them, *i.e.*, both *intrusive* and *effusive* types are represented.

Their age has not yet been definitely fixed, but the rocks are known to be older than Silurian, and therefore are provisionally classed as Pre-Silurian.

(2) *Basic Group.*

The occurrence in the district under review of a broad belt of basic rock, gabbro, norite, pyroxenite, and serpentine, evidently genetically related to the acidic types described below, is quite in accord with observations recorded by officers of the Geological Survey in other districts.

Mr. L. K. Ward recorded the occurrence at North Dundas⁽³⁾ of a series of similar rocks, connected also with acid rocks. In fact, the belt of basic rocks described in this report is probably continuous with that recorded at North Dundas. It has a general north-north-west strike, and is cut through by the Pieman River near its junction with the Huskisson. As shown in the accompanying map, north of the junction of the Wilson and Harman Rivers it is cut off by granite. This granite forms a long spur of the Meredith Range, running out westward. Mt. Ramsay appears to be a continuation of the spur. The basic rocks appear again at the Bald Hill, north of the Meredith Range, where they are well developed.

For a part of its course the Wilson River marks the junction between the basic eruptives and the Silurian sedimentaries, which they have evidently intruded. The Wilson River cuts diagonally through the belt, and forms for a time below the junction with the Harman, the eastern boundary of the belt. Other occurrences of basic rocks associated with acid ones of somewhat later age have been summarised by Mr. Ward.⁽⁴⁾

Unfortunately, this portion of the district examined was rather far removed and difficult of access from the

⁽³⁾ Geol. Surv. Tas. Bulletin, No. 6, pp. 18-24.

⁽⁴⁾ *Op. cit.*, pp. 29-30.

only two camps available, and consequently the writer's examination of the locality was necessarily somewhat hasty and of a general character. At no point visited was any actual contact observed, either with Pre-Cambrian slates, Silurian sedimentaries, or Devonian granite. The covering of surface soil is so thick and the undergrowth so dense that rock outcrops are almost completely hidden. Hence, definite contact metamorphic effects were in no case observed *in situ*. In consequence of these difficulties, the geological boundaries of the group, as shown on the map, are approximate only.

The topography of this portion of the district has already been dealt with. A series of comparatively low ridges, divided by streams forming part of the drainage system of the Wilson and Huskisson rivers, represent portion of the dissected peneplain of the old Pieman River. Between the Wilson and Harman Rivers there is a well-defined ridge rising to a height of about 1400 feet, and presenting a steep face to the south. Between this steep face and the junction of the two rivers referred to, a fairly extensive alluvial plain is developed, which is worth prospecting for tin and osmiridium. The rock-types represented would seem to belong rather to the basic than the ultra-basic divisions, although most likely both types were represented in the unaltered rocks. The rocks are so largely serpentinised that it is quite impossible in many cases to determine what the original rock was. Much of it was doubtless peridotite and olivine gabbro, although neither of these types was represented in the specimens collected.

Although there is a considerable variation in the rock-type from point to point in the area, the series as a whole is characterised by its low percentage of silica and high percentage of ferromagnesian constituents.

A fairly typical specimen collected from a hill about 1 mile south-west of the Harman River crossing, on Jones' Track, is macroscopically of a greenish-grey colour, and of somewhat variable grainsize. Comparatively large flakes of pyroxene showing good cleavage faces are prominent. These are as much as 7 by 5 millimetres. They are enclosed in a groundmass of feldspathic material and greenish pyroxene of finer grainsize. A little scattered pyrite is noticeable.

Microscopically the rock is holocrystalline and of coarse grainsize. The fabric is poikilitic, the pyroxene crystals

acting as hosts and enclosing idiomorphic feldspars, which appear to penetrate it. The feldspars are almost completely saussuritised in many instances, and extinction angles are rather indefinite, but labradorite seems to be the feldspar represented. The pyroxene is monoclinic diallage and occurs in allotriomorphic masses, largely moulded on the feldspars. The pyroxenes have in some cases been converted to uranalite. The alteration is seen in some individuals to commence from the periphery of the crystals, the light-green actinolite growing inwards in radial tufts and brushes of fine needles, which gradually spread out over the crystal and finally completely replace the original, forming pseudomorphs of uranalite after pyroxene. The feldspars have also been attacked, and a few individuals show abundant green actinolite needles. It is interesting to note that to some extent the uranalite, itself secondary, has in turn been partially converted to chlorite. Ilmenite is present in small amount, partially converted to leucosene. There are also scattered idiomorphic crystals of magnetite and chromite. No olivine appears in the slide. The iron ores, which are included in both the saussurite aggregates and also in the diallage, have evidently been the first to crystallise, followed by labradorite, and finally diallage.

The rock is a gabbro, saussuritised and partially uranalitised.

Another type of rock is represented by a specimen collected from the Harman River near Jones' Track to Waratah. Macroscopically it is dark-greenish black in colour, with flakes of pyroxene distinguishable in a serpentinised groundmass. This rock is typically developed in several portions of the area of basic rocks under consideration.

Microscopically the rock is seen to be largely converted to serpentine. Saussurite aggregates are also present, representing original feldspars, now entirely decomposed. No recognisable feldspar remains. The pyroxene is mostly orthorhombic enstatite, with a few fragments of unaltered monoclinic diallage. The rhombic pyroxene is largely converted to the serpentinous mineral bastite. While retaining the form of the pyroxene, the bastite consists of aggregates of minute fibres arranged longitudinally, the continuity of the fibres being frequently interrupted by transverse fissures, which in turn are filled with serpentinous material. Some of the serpentine aggregates

show typical mesh structure, suggesting its derivation from olivine, although no fragments of the latter mineral now remain.

Another facies represented, and found to form the outstanding pinnacles a little north of the junction of the Harman and Wilson rivers, is an exceedingly tough rock, of a greenish-grey colour, which in the hand specimen shows only crystals and plates of greenish pyroxene, with included chromite. It weathers to a reddish-brown rock, and finally yields a red soil very rich in iron, which gives the steep hill-sides, which carry only stunted shrubs, a general dun-brown appearance.

In the hand specimens, grains of chromite are noticeable in the pyroxene. The pyroxene is in plates of somewhat varying size, up to $\frac{1}{2}$ -inch by $\frac{1}{4}$ -inch. No other constituents are visible.

Microscopically the rock is seen to consist largely of rhombic pyroxene (bronzite), with some monoclinic pyroxene (diallage), a little olivine, serpentine, and chromite. There is no felspar present. The rock is holocrystalline, grainsize being variable, individual plates and crystals being medium to coarse. The bronzite is hypidiomorphic, and in some instances idiomorphic, while the diallage is generally allotriomorphic. Olivine is present in small residual grains with a little serpentine, alteration to the latter mineral being almost complete. The chromite is idiomorphic, and has evidently been the first mineral to crystallise out from the magma, while the rhombic is evidently older than the monoclinic pyroxene. The rock is a pyroxenite, and would be called websterite.

These rocks grade into serpentine, various types from unaltered igneous rocks to pure serpentine being observed in different places. The serpentine, resulting, as it does, from the alteration of different rock-types, naturally varies from point to point: various shades of green predominate, from a light yellow-green through olive to a deep greenish-black colour. According to the extent serpentinisation has proceeded, various fragments of the original constituents are observed. The serpentine is traversed by veinlets of chrysotile asbestos, generally of very short fibres, the greatest width of vein (*i.e.*, length of fibre) observed *in situ* being $\frac{1}{2}$ -inch, the average width about $\frac{1}{8}$ -inch. The chrysotile was noted first on the western bank of the Wilson River, where it is joined by Jones' Track to Waratah, but afterwards at various other points between the Wilson and Harman Rivers.

Even where the rock is thoroughly serpentinitised abundant crystals of fresh chromite and magnetite are readily distinguishable by the naked eye. It would seem that these two minerals are intimately intergrown, for some serpentine was crushed and vanned, and the resulting concentrate of black iron minerals subjected to magnetic treatment. The magnetic portion was carefully re-concentrated several times, to minimise the risk of picking up mechanically mixed, non-magnetic material, and was then found to react very definitely for chromium, and also to leave a black residue insoluble in hydrochloric acid. On the other hand, the non-magnetic portion was insoluble in acid, and answered all tests for chromite. In hand specimens these minerals generally show octahedral outlines.

With regard to this group as a whole, it is evident from field relationships that it is intrusive into the Silurian sediments. It is therefore Post-Silurian, and the writer is in full accord with the theory postulated by Mr. Ward in accounting for a similar occurrence at North Dundas,⁽⁵⁾ viz., that both basic and acidic groups represent different phases of igneous activity in Devonian time. Differentiation having played an important part in causing a partial concentration of the more basic constituents of the original magma, these were forced into their present position by a release of pressure. At a somewhat later period the acidic portion of the magma was forced up into the overlying strata, and solidified as the granite *massif* of Meredith Range. Thus the acidic and basic rocks are assumed to be genetically connected, having originated in the same parent magma.

The original contour of this igneous belt of rocks cannot now be determined. That consolidation must have taken place at depth, and under considerable pressure, is evident from the structure of the rocks under consideration. They are all holocrystalline, excepting where serpentinitisation has destroyed the original structure. It is probable that a considerable amount of rock material has been removed by degradational forces. Serpentine as a rock, although soft, offers great resistance to surface weathering agencies, but in this district these forces have been at work for a very long period. We know that the originally overlying sedimentaries have been removed, but it is impossible to say how much of the igneous rock has gone.

Serpentinitisation appears to have affected a considerable portion of the exposed area of this group of rocks. From

(⁵) *Op cit.*, . 99-32.

the observations of the writer, it would appear that this alteration has been far more complete towards the edges than towards the centre of the group. While this cannot be enforced too strictly, it seems to be generally true. While towards the margins the rock is completely converted to serpentine (frequently with small veins and threads of asbestos), the more central portion of the mass consists of gabbro and norite, merging into pyroxenite. In few cases was olivine shown to be present in the rock, but it seems likely that much of what is now serpentine may have originally been peridotites and other olivine-bearing rocks. If this is correct, it would seem that magmatic differentiation has played its part, and that the more basic portion of the molten mass has segregated towards the edges of the cooling mass before consolidation took place.

Without here entering fully into a discussion of serpentinisation and its causes, it may be stated that it is now recognised that weathering is not solely responsible for the phenomenon, since in some instances olivine rocks are known to occur at the surface, while on the other hand serpentine is proved by mining operations to occur at considerable depths below the surface, beyond the reach of weathering agencies. It seems probable, therefore, that the alteration is due partly to the percolation of heated waters. Such waters might be liberated at the final stages of consolidation of the basic magma.

It is rather surprising to find so little sign of contact-metamorphic effects on the sediments into which these rocks have been intruded. The latter are but slightly altered at the contact, a silicification and hardening of the sediments being noted in a few cases, but not extending many yards from the contact. In general, however, the line of contact is hidden by surface detrital matter and soil.

Microscopic examination of the slides prepared from rocks in this area has shown that saussuritisation of the feldspars has taken place, accompanied in some instances by uranalitisation of the pyroxenes. These changes are both recognised as being due primarily to pressure, indicating that the rock-mass has been subjected to pressure at some time subsequent to consolidation. The intrusion of the acid rocks in Devonian times, but slightly later than the basic ones, and which has so considerably altered the surrounding sediments, might, perhaps, account for this

alteration. The sediments are metamorphosed right from the granite to the contact with the basic rocks.

At North Dundas, Mr. Ward ⁽⁶⁾ has suggested that the increase in bulk due to serpentinitisation may account for the conversion of pyroxene into amphibole. The same argument would apply in this instance.

(3) *Diorite and Diorite Porphyry.*

On the Stanley Reward track, about 36 chains beyond the Mt. Lindsay turn-off, is an outcrop of a dark greenish rock, evidently not belonging to the surrounding sedimentary series. The outcrop is about half a chain in width on the track. An attempt to trace the extent of the surface outcrop was not very successful, owing to the heavy undergrowth, and general absence of rock outcrops. It apparently occurs in dyke form, intrusive into the surrounding slates. Contact metamorphic effects were not marked, but this fact is not surprising considering that the surrounding sedimentaries are metamorphosed by the granite intrusion. In hand specimens the rock is of a dark greenish colour owing to the predominance of the ferromagnesian constituent. It is fine grained, and, in addition to the dark green ferromagnesian minerals, feldspars are to be noted in the groundmass, usually of small size, with occasional phenocrysts somewhat larger than the average feldspars of the rockmass (phenocrysts up to about 2 mm. \times 1 mm. being noticed). Scattered pyrite is seen to be present in the rock, with a little chalcopyrite. The metallic minerals have evidently been introduced subsequently to the consolidation of the rock, for they occupy in some instances minute fissures in the rockmass.

On decomposition the rock yields a yellow-brown clay. Microscopically the rock is seen to be holocrystalline, and to consist essentially of hornblende and plagioclase, with occasional orthoclase phenocrysts. There is excess of hornblende in the groundmass of the slide, accompanied by tabular feldspars showing idiomorphic outlines and frequently penetrating the amphibole. The latter mineral has evidently crystallised out later than the feldspars, being largely moulded on them. Part of the hornblende is bleached. The feldspars are clouded by decomposition products, rendering extinction angles indistinct, but these point to andesine being the triclinic feldspar present.

⁽⁶⁾ *Op. cit.*, page 31.

There is a good deal of magnetite scattered through the slide, and a little pyrite in irregular masses. Running through the slide are several roughly parallel veinlets filled with green chlorite, and containing pyrite. These give the rock a somewhat schistose appearance. A little clear felspar appears here also in small grains; this is probably albite. The rock has evidently been subjected to some alteration, but is probably a diorite porphyry.

Occurring on the southern slopes of Parson's Hood, where it forms bold cliffs towards the head of Tulloch Creek, 1850 feet above sea-level, is a dark greenish rock of fine grain, the only constituent recognisable in hand specimens being phenocrysts of orthoclase felspar, up to about 4 by 6 millimetres. The rock might at a glance very easily be overlooked, situated as it is in sediments which have been subjected to intense metamorphic action, and which are themselves converted to hard igneous-looking cherts and quartzites. The extent could not be exactly traced, but was not large, the occurrence suggesting dyke form.

Microscopically this rock somewhat resembles that described above. The groundmass consists largely of green hornblende in irregular aggregates, with a smaller amount of felspar in minute tabular crystals. The plagioclase is kaolinised, and consequently the extinction angles are indefinite, though they seem to be small. Orthoclase is present in idiomorphic phenocrysts. There is much magnetite in irregular masses associated with the hornblende, one result, apparently, of the decomposition of that mineral. The hornblende has in part been converted into green blades of actinolite.

There is a veinlet filled with hornblende, and carrying a little pyrite, traversing the slide.

Apatite is present in small quantities.

The rock is evidently a dioritic dyke rock. It somewhat resembles the lamprophyres, but has not the typical structure. It may be called a diorite porphyry.

In Tulloch Creek abundant boulders were noticed of an igneous rock which had not been observed *in situ* on the field. Of a predominant dark greenish colour, the rock is seen on closer examination to be composed largely of a green ferromagnesian mineral with distinguishable felspars, and to be of even and medium grainsize.

Microscopically the rock is seen to be holocrystalline, and to be composed essentially of crystals of green horn-

blende with hypidiomorphic outlines, and idiomorphic feldspars. Both plagioclase and orthoclase feldspar are present, the latter not in large amount. The variety of plagioclase is oligoclase. Both brown and green hornblende occur. At times the centre of a crystal is brown, and the outer fringe green, the two being optically continuous. The hornblende has completed crystallising later than the feldspar, which it partly encloses, giving a somewhat ophitic facies to the rock. Abundant apatite in minutely slender prisms occurs included in the later formed minerals. The feldspars are pierced by blade-like needles of actinolite. The rock is a diorite. Its occurrence is rather unexpected, but there is little doubt but that it is intrusive into the Dundas slate series at some point not exactly located, on the southern slopes of Parson's Hood. Its extent also is unknown.

Very similar to the above in structure and general characteristics is a rock occurring *in situ* on the Mt. Ramsay track about $\frac{1}{2}$ -mile to $\frac{3}{4}$ -mile west of the Harman River. The extent noted was not very large. Microscopical examination shows this rock also to be a diorite, somewhat finer in texture and slightly richer in feldspar than the type just described. As will be seen on reference to the accompanying map (Plate II.) it occurs near the margin of the basic rocks. The writer at first thought this rock formed part of the basic group, but further examination led him to the conclusion that it occurred in dyke form, although paucity of outcrops rendered proof difficult.

The age of the rocks just described is assumed to be Devonian. They appear to have been intruded into the Dundas slate series before the invasion of the granite mass now forming the Meredith Range, and probably after the eruption of the basic rocks, although the evidence for this latter statement is merely presumptive.

They have been derived from the same magma which gave rise to both the acid rocks represented by the granite of the Meredith Range, and the basic rocks of the Wilson River belt, and form an intermediate group.

(4)—*The Acidic Group.*

This group is of extreme importance in the field, being genetically connected with the occurrence of tin. It includes granite, granite-porphyry, aplite, and quartz-tourmaline.

The granite forms the southern portion of the Meredith Range *massif*, a huge granite mass which now forms the bulk of the Meredith Range.

The age of the granite is regarded as Devonian. There is no definite proof of this in the area under review, but it has been repeatedly remarked in the publications of the Geological Survey that the intrusion of the granite occurred between Upper Silurian and Permo-Carboniferous time. It is undoubtedly intrusive into Upper Silurian strata, and abundant boulders of it occur in the basal conglomerates of the Permo-Carboniferous system. Hence it is assumed to be of Devonian age.

The granite is similar to that now known to be widely distributed throughout Tasmania, and so often referred to as the Tasmanian "Tin Granite," since it is in most cases accompanied by tin-deposition, in contradistinction to the older granitic rocks of Pre-Silurian age, which have so far not been shown to be stanniferous.

Macroscopically, the rock is seen to be a light-coloured biotite granite, tending to porphyritic in places. The constituents of the normal granite in their order of relative abundance are orthoclase, plagioclase, quartz, and biotite; tourmaline is sometimes present in addition.

The feldspars are usually $\frac{1}{2}$ to $\frac{3}{4}$ inch in length, with a second generation of smaller crystals in the groundmass. The orthoclase is white, no pink orthoclase being noticed on the field. It is the excess of orthoclase which gives the rock its general light-coloured appearance. The plagioclase is not very noticeable in hand specimens. The quartz is in very fresh glassy crystals about $\frac{1}{8}$ to $\frac{1}{4}$ inch in diameter. Biotite is in scattered crystals throughout the mass, individual crystals being exceptionally $\frac{1}{8}$ -inch across, but usually smaller.

When the granite becomes porphyritic, the phenocrysts are of white orthoclase.

As is only to be expected the granite varies somewhat in texture and composition. Going north along the Stanley Reward water-race (where a good section of the granite was exposed) it was noticed that north from Minor's Creek the granite was almost uniformly of somewhat finer average grain-size than that described above. Whether this represents an intrusion of slightly different age to that of the main granite mass, or whether it is due to differentiation *in situ* of the original magma, or to slight variations in the conditions under which cooling took place,

was not definitely determined on this occasion. The writer is inclined to the opinion that the second and third factors account for the difference noted.

A microscopical examination was made of a slide cut from a specimen collected on the race near Rocky Creek. The following minerals are seen to be present:—orthoclase, quartz, plagioclase, biotite, zircon. The texture is holocrystalline, relative grainsize even, and on the average medium to coarse in size. The orthoclase frequently shows Carlsbad twinning, and many of the crystals show typical cleavages. The plagioclase shows the low extinction angles of albite and albite-oligoclase; abundant albite twins are noticeable with extremely fine lamellations. Some crystals show zonary banding, the outer layers of material being more acid than the interior. A good many of the feldspars are more or less decomposed. The decomposition seems to commence from the centre of the individual crystals, and gradually spread outwards towards the periphery. In some individuals decomposition has taken place in certain defined zones, the centre and edges of the crystal remaining fresh. Biotite has crystallised out early, showing hypidiomorphic outlines, with frayed-out ends. Although the crystallisation of the quartz and feldspar has been to some extent contemporaneous, as shown by inclusions of quartz in some of the feldspar crystals, the quartz has evidently been the final mineral to finish crystallising out from the magma, as it fills interstices, and is largely moulded on the feldspars. Zircon in scattered highly idiomorphic crystals occurs included in other minerals. Some of the decomposition products contain a little sericite, and also kaolin. The rock is a biotite granite.

One striking feature, more noticeable perhaps on the summit of Parson's Hood than at any other spot visited, is the occurrence in the granite of quartz-tourmaline nodules. These are very noticeable on the weathered granite surfaces, for they stand out as more or less spherical balls, and as weathering proceeds these nodules are often freed, being more resistant to the attacks of atmospheric agencies than the enclosing granite mass. They consist essentially of black tourmaline with varying amounts of quartz. They are due to the operation of magmatic differentiation in the original magma, the minerals now forming these nodules having gradually segregated and solidified as cooling proceeded.

The occurrence of exactly similar nodules has been studied in detail by Mr. G. A. Waller at Mt. Heemskirk,

where they appear to be extremely abundant and particularly well developed. Mr. Waller has dealt in detail with the occurrence and mode of origin in his official report.

In the field these nodules were not observed in the coarser-grained granite; they appear to be confined to the fine-grained varieties.

On the summit of Parson's Hood also were noticed abundant veins of pure black tourmaline. These were of different widths in different localities, from less than 1 inch to as much as 8 or 9 inches. These are continuous for considerable distances, and as in the case of the nodules, are very noticeable on weathered surfaces, standing out in relief.

The tourmaline evidently occupies contraction-cracks in the granite. After the outer crust of the granite has solidified, as cooling has proceeded, it has necessarily been accompanied by contraction, and the already consolidated granite has been fissured. This fissuring has allowed the escape of the active mineralisers, gaseous emanations rich in boron, which have resulted in the formation of tourmaline.

Frequently these fissurés appear to have a north-west and south-east trend, but others also occur striking at widely differing angles.

Another fact noticed in the field was the occurrence of dark-coloured masses in the granite. These, on examination, were found to consist essentially of biotite mica, generally very fine grained, with small amounts of feldspar and quartz, forming irregular-shaped masses varying considerably in size. These also are due to segregations of the more basic constituents of the molten magma.

A thin slide cut from one of these basic segregations was examined microscopically, and was seen to consist of abundant brown biotite, with plagioclase, quartz, orthoclase, muscovite, apatite, and magnetite. The rock is holocrystalline, of fine grain size, relative size being even, and with a granitoid fabric. The apatite crystallised out early, occurring abundantly as very slender prisms included indiscriminately in quartz and feldspar, and frequently penetrating the biotite. Magnetite occurs sparingly, in sporadically distributed crystals, whose idiomorphic outlines show that it has been one of the first minerals to crystallise out. Biotite is brown in the basic segregation, but green in the normal granite, which shows in one portion of the slide. It is abundantly distributed in hypidiomorphic crystals, sometimes so highly coloured

as to transmit very little light. Its crystallisation has evidently preceded the feldspars, since fragments of biotite are included in the feldspars, and the feldspars are in part moulded on the biotite. That the crystallisation of the feldspar has been in part earlier than the mica is shown by the fact that in some individuals the mica wraps round the hypidiomorphic feldspar. The biotite is intergrown with a little muscovite in some instances, the two being in optical continuity. The plagioclase is mostly clouded by decomposition products, and extinction angles are indefinite; orthoclase is but sparingly developed, and it, too, is partly decomposed. Quartz has evidently commenced crystallising out early, as inclusions occur in both feldspar and biotite, but it has been the final product of consolidation.

Another variation of the normal granite is a fine-grained light coloured granite porphyry occurring in dykes traversing both the normal granite and the adjacent sedimentary rocks. The same type was noticed at the contact with the Pre-Silurian slate series.

The granite porphyry typically developed is an almost pure white rock, with fine crystals of biotite and quartz scattered through a groundmass of quartz and feldspar. Microscopically an examination was made of a section cut from the dyke occurring in the contact metamorphic zone at the Mt. Lindsay Mine. The minerals present are quartz, orthoclase, plagioclase (oligoclase?), biotite, muscovite, chlorite, pyrite, apatite, zircon. In crystallinity the rock is hypocrystalline: the average grain size is medium, relative grain size being variable. The fabric is granitoid. The structure is porphyritic, phenocrysts of quartz and orthoclase feldspar (and occasionally biotite) occurring in a granular to glassy groundmass. The quartz phenocrysts are generally rounded and eaten into by the corrosive action of the groundmass while still molten, but in some instances still show traces of idiomorphic crystal forms. They contain inclusions of glass, and sometimes flakes and shreds of biotite. The orthoclase phenocrysts are not very abundant; they are hypidiomorphic, and show typical Carlsbad twinning. To some extent they are moulded on the quartz, and contain included quartz; they are partly decomposed. Biotite is scarce, occurring in occasional shreds in the granular groundmass of quartz and feldspar. Much of the feldspar is rendered cloudy by decomposition products, but in some cases multiple twinning on the albite law is noticeable, the extinction angles pointing to oligoclase, though they are rather indefinite. A little scattered muscovite is present. Chlorite occurs in

tufts and aggregates, sometimes entirely replacing the felspar crystals. Pyrite is not abundant, but occurs in minute highly idiomorphic individuals. Apatite and zircon are distinguishable under the high power in typical prisms included in the later-formed minerals. There is a little glass in the groundmass of quartz-felspathic material. Inclusions arranged in definite lines were noticed in quartz, but could not be determined with the objectives available.

The rock is a granite porphyry, with a quartz porphyry facies.

Veins and dykes of aplite were noticed in places traversing the normal granite.

Other acid rocks closely associated with the granite, and of economic importance, are the quartz-tourmaline veins and dykes, which are abundant throughout the district. These are of importance, because of the associated cassiterite in many cases. Much of the alluvial tin contained in the adjacent flats has probably been derived from these veins. Even the most casual observer could not but be struck by the great abundance of boulders of quartz-tourmaline on all the granite hillsides, and in all the watercourses heading from the granite country.

These boulders are of all sizes, and are frequently well-rounded. They occur almost to the exclusion of the granite some short distance from the igneous mass. Within the boundaries of the granite itself huge boulders of granite are abundant. The relative abundance of the quartz-tourmaline boulders is due partly to their superior hardness, and also to the fact that quartz very strongly resists the attacks of weathering agencies, and tourmaline is far more stable than the felspar and mica of the granite, which are very prone to decomposition, allowing the more rapid disintegration of the rock.

An examination shows a great variety in the nature of these quartz-tourmaline boulders. Although consisting apparently of but the two minerals, quartz and tourmaline, the relative proportions of these vary considerably, and the manner in which they have crystallised, causing the variations in the appearance and structure of the resultant rock. The mode of origin of the different varieties is the same.

Typically the tourmaline occurs in aggregates of fine prismatic crystals, frequently radiating, in a groundmass of small idiomorphic crystals of quartz. Frequently two generations of quartz are present, larger prismatic crystals

up to $\frac{1}{4}$ -inch in diameter in a groundmass of saccharoidal quartz, consisting of idiomorphic crystals of microscopic size. Mirolitic cavities are sometimes present, and into these project small prisms of quartz, which in their turn are coated by minute pyramidal quartz crystals, only noticeable under a powerful magnifying glass.

The tourmaline is of both black (iron) and green (alkali) varieties, with intermediate colours. The black generally appears to be more coarsely crystalline than the green. A very striking feature of the tourmaline is its frequent occurrence in masses of radiating crystals replacing the felspar of the original granite. The pseudomorphs after felspar are perfect, the boundaries of the pseudo-crystals being very sharply marked, and showing out very distinctly in the groundmass of white and glassy quartz. Nowhere has the writer seen such perfect examples of pseudomorphs of tourmaline after felspar. This occurrence gives a clue at once to the mode of origin. These tourmaline pseudomorphs sometimes enclose a little quartz in idiomorphic grains. Occasionally the central core of the mass is of quartz and the crystal boundaries of tourmaline.

Scattered through the main quartz groundmass is a little tourmaline, here, too, often in aggregates of minute, needle-like prisms.

In some specimens tourmaline occurs in the groundmass in abundance, giving the groundmass a predominating dark colour.

One specimen obtained shows aggregates of slender tourmaline prisms up to $1\frac{1}{2}$ inch in length, with somewhat coarser prisms of clear glassy quartz in a quartzose groundmass, through which are scattered very abundant minute needles of tourmaline. Minute mirolitic cavities are of frequent occurrence, all lined with microscopic quartz crystals. In some instances larger quartz prisms are encrusted with these minute pyramids; in others it is interesting to note that slender prisms of tourmaline projecting into the cavities form the core for these crusts, showing that some part at least of this encrusting mass of crystals was deposited after the formation of part of the quartz and of the tourmaline.

The numerous boulders referred to are derived from veins and dykes either in the granite itself or in the adjacent country-rock. Examples of both occurrences are given in a later part of this report.

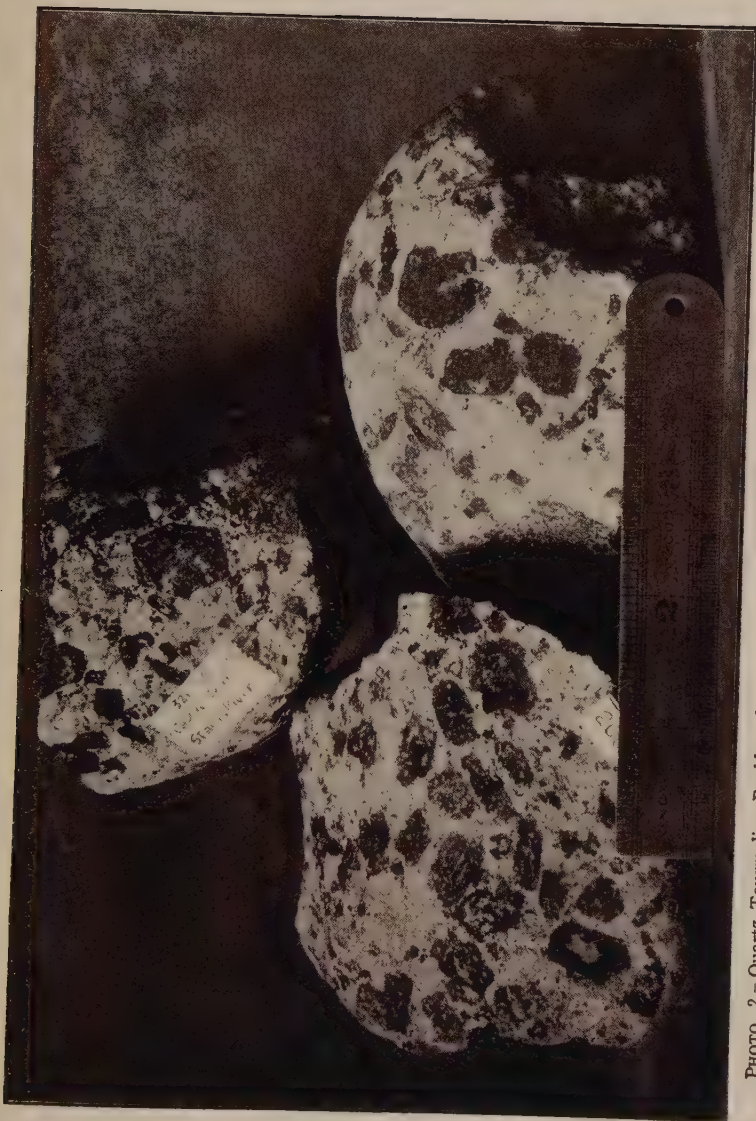


PHOTO. 2.- Quartz Tourmaline Boulders from Stanley River, showing Pseudomorphs of Tourmaline after Felspar.

[L. L. Waterhouse, Photo.]

(5)—*Summary of the Sequence and Relationships of the Igneous Rocks.*

The three classes of igneous rocks have been described in the order of their appearance in the positions they at present occupy in the field.

The basic, intermediate, and acidic types are all genetically connected, being derivations of the one parent magma. The original magma having undergone a partial differentiation *in situ*, on a partial release of pressure the basic portion has been forced up into the superincumbent strata; it would appear that at this time the thickness of sedimentary rocks must have been considerable, consolidation of the mass taking place under pressure, and producing the coarsely crystalline plutonic types of rocks described. Reference has been made to the fact that a partial differentiation may have taken place *in situ* before consolidation.

At about the same time, or probably slightly later, another portion of the magma was forced up into the overlying rocks, chiefly in the form of dykes of limited extent, now forming diorite and diorite porphyry. The difference in texture of these rocks is evidently dependent on the conditions of consolidation, more rapid cooling of the smaller masses producing the diorite porphyry.

Later still, but still closely following the basic rocks, was the eruption of the acid portion of the magma, which on solidification has formed the present Meredith Range *massif*.

The latest phase of this intrusion of acid rocks occurred after the consolidation of the outer crust, and was marked by the extrusion of material which formed granite-porphyry and aplitic dykes. It was at this period that the quartz-tourmaline veins and dykes were formed, and that tin was introduced. The more detailed discussion of the formation of the ore-bodies will be found in another part of this report.

B.—SEDIMENTARY ROCKS AND THEIR MODIFICATIONS.

The sedimentary rocks of the district fall naturally into several groups, which will be dealt with separately. It is to be noted that instead of treating the altered sedimentaries under a separate heading as "metamorphic" rocks, it has seemed advisable rather to describe them here.

The rocks dealt with in this section will be—(i) the schists, quartzites, and slates of probable Pre-Cambrian age; (ii) the slates, sandstones, and tuffs of Pre-Silurian

age; (iii) the dolomite of Pre-Devonian age; (iv) the slates, sandstones, and limestones of Silurian age; (v) the older river gravels of Pleistocene age; and (vi) the Recent alluvial deposits—the two latter being unconsolidated.

(1)—*The Schists, Quartzites, and Slates of Probable Pre-Cambrian Age.*

From a vantage point of view, such as the summit of Mt. Livingstone, whence a more or less complete panoramic view of the district is obtained, one is forcibly struck by the appearance of the country stretching west and south. Forming portion of the old Pieman peneplain already referred to,⁽⁷⁾ now dissected by members of the present drainage system, and uniformly covered with button-grass (except in the river valleys), it presents a marked contrast to the rugged mountainous country to the north and east, which is all heavily timbered.

This more open button-grass country on examination proves to be composed of a series of schists, quartzites, and slates. The western limit of the formation was not located, but it appears to extend at least to the Pieman River.⁽⁸⁾

The prevailing type, at some little distance beyond the granite contact, is a hard, white quartzite, cut through in all directions by veinlets of barren-looking white quartz, and a good deal crushed, in addition to being hardened. This evidently represents an old sandstone. Interbedded are occasional comparatively narrow belts of dark-blue fissile slates, with perfectly developed slaty cleavage. These are micaceous, and have evidently been subjected to intense crushing.

Near the granite the alteration has been intense. The original sediments now consist of schists, of which the chief varieties would appear to be quartz schists, quartz-biotite schists, quartz-muscovite schists, quartz-biotite-actinolite schists.

On the summit of Mt. Livingstone the rocks are rendered very schistose, and have a north and south strike. The dip is almost perpendicular, in some cases slightly to the east. This explains the shape of the main peak being a razorback, with north and south axis, falling away very rapidly to the east. In appearance the rocks are bluish when fresh and undecomposed, reddish when oxidised,

(7) *Vide* page 4.

(8) *Vide* Plate II.

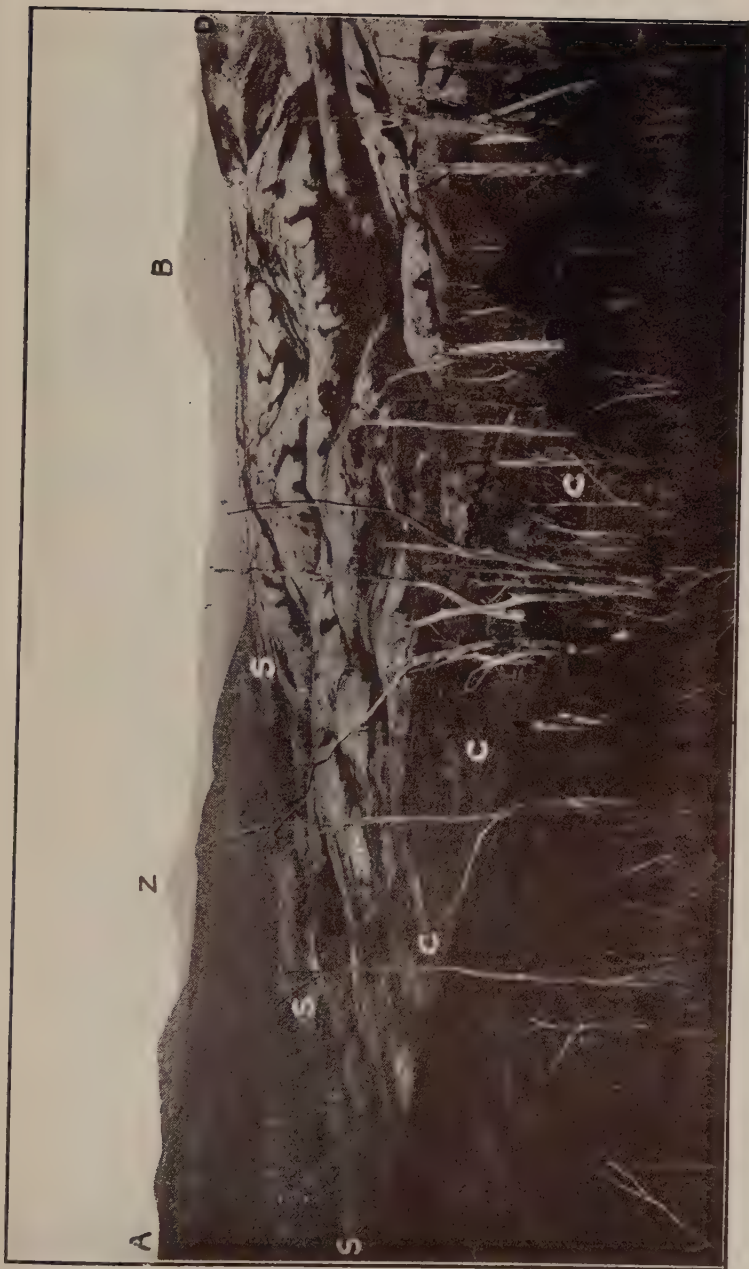


PHOTO. 3—View of Pre-Cambrian Schist Country, West of Stanley Reward.

[*L. I. Waterhouse, Photo.*]

being bleached white on exposed surfaces. The rock is frequently crumpled, the bands of varying composition being puckered into beautiful folds. The schistose banding, well defined in the freshly-broken rock, is accentuated by weathering, the softer micaceous material being decomposed more rapidly than the more quartzose portion of the rock, leaving the latter standing out in marked relief as sharp ridges, with intermediate furrows representing the weathered-out micaceous bands. These planes of schistosity form excellent percolation channels for surface waters, which, in penetrating, deposit crusts of limonite, and weaken the rock so much that large flakes break away where crossed by transverse cracks.

A thin section of a fairly typical rock from the summit of Mt. Livingstone shows a groundmass of quartz grains forming a regular quartz mosaic, though with a defined schistose banding. With the quartz is some clear albite. In places a little sericite in fine shreds is noticed, and in the groundmass a small quantity of actinolite.

There is a little limonite coating the quartz veins in places, evidently secondary. The rock is a quartz schist.

A variety of the same rock is that outcropping in Livingstone Creek, on Section 4958-M, at the head of the alluvial flat. It is a handsome rock, light in colour, with greenish micaceous bands.

The microscope reveals a quartz-albite mosaic, with brown biotite, and fairly abundant fragments of muscovite. Chlorite is present in tufts and aggregates, and andalusite is developed, showing typical pink pleochroism. This rock, too, has a well-developed schistose structure, and is to be classed as a quartz-mica schist. Another variety of these contact schists is a fairly common one, west of the Stanley Reward flat, in which there is not a very marked schistose banding in hand specimens, but the rock appears to consist of rounded quartz blebs in a micaceous groundmass.

A specimen collected from Livingstone Creek was sectioned, and microscopically proves to be a quartz-muscovite schist, the most abundant minerals being quartz and muscovite, with a little albite, some fine shreds of sericite, and well-developed chlorite.

The rocks described above all occur near the granite intrusion, and may be considered as extreme types. Undoubtedly they owe their present structure largely to the effects produced by the granite intrusion. But even

far from the exposed borders of the granite the series still shows signs of great alteration, in the way of silicification and schistosity.

One rather remarkable rock-type may be described here: although up to the present no notice has been taken of it, it well merits prospecting for tin values, which may be present. A similar rock has previously been reported from Mt. Heemskirk⁽⁹⁾ by Mr. Waller.

The rock referred to is a very handsomely-banded black and white rock, consisting of alternate bands of quartz and black tourmaline. It occurs fairly abundantly as boulders and pebbles in the Stanley Reward alluvial wash, and is locally known as "tiger-cat stone." It was found by the writer *in situ*, outcropping on the low spur bounding the Livingstone Creek alluvial flat to the west. Here it is interbedded with quartz-mica schist, such as that described above.

The rock affords an excellent example of replacement of country-rock by vapours and solutions emanating from a neighbouring intrusive igneous mass. The schist, already crushed and crumpled by the intrusive granite, has been replaced particle by particle by quartz and tourmaline. The replacement has been so complete that the resulting rock represents faithfully all the variations in structure of the original schist. Where the schist has been folded the quartz-tourmaline reproduces the folds. It is rather surprising to notice the manner in which the composition of the schist has influenced the "pseudomorph"; mere black threads of tourmaline in a band of white quartz are persistent over many inches, while mere threads of quartz also continue without interruption in a band of apparently pure tourmaline.

Reference has already been made to one type of quartz-mica schist in which the quartz occurs as aggregates in a groundmass of mica, as distinct from the more usual banded variety. This type is also represented in the quartz-tourmaline replacement rock. Here we have a black and white spotted rock, instead of a banded one. White quartz aggregates are scattered through a groundmass of finely crystalline black tourmaline. Finer quartz aggregates are to be noticed in the tourmaline groundmass.

It seems evident that the mica has been attacked by the boron vapours, and converted to tourmaline, while the quartz has remained unattacked or has recrystallised.

⁽⁹⁾ "Report on the Tin Ore-deposits of Mt. Heemskirk," by G. A. Waller, p. 6.

A thin section of one of this interesting series of rocks shows that the only constituents present (in the particular sample sectioned) are quartz and tourmaline.

No tin was observed in any of the samples examined, but these rocks appear never to have been prospected, probably owing to their character not having been recognised. It is quite likely that some cassiterite may have been introduced with the tourmaline, and it is recommended that a trial be given, as the rocks occur *in situ* within about 5 chains of the Stanley Reward alluvial workings.

With regard to this series as a whole, the true strike and dip cannot be determined with absolute certainty. Observations were made in various places, and it was found that there was little agreement near the granite contact. Further away the readings were more consistent, and an average value indicates that the beds strike N. 66° W., and dip north at 80°. This value has been adopted in the geological sections accompanying this report.

It has been stated that the series is probably Pre-Cambrian. This statement needs some amplification.

It must be admitted at the outset that the evidence for a definite determination of age is scanty.

By both Mr. Montgomery⁽¹⁰⁾ and Mr. Waller⁽¹¹⁾ this series was not differentiated from the Dundas slate series further to the east, both being classed as Silurian. Later investigation has shown that the latter are undoubtedly Pre-Silurian. It seems that these quartzites and slates are older still.

The striking change in the nature of the country south and west of Four-mile Creek has already been referred to. On coming out on to this open button-grass country, free of timber, in contrast to the almost impenetrable scrub, one is compelled to seek an explanation. This is found in the striking difference in the soil: previously clay, it has now become very open and siliceous, and very shallow, compared with the deep clay frequently noted. In the Pre-Silurians, as developed in the district, the predominating members are slates (and fine tuffs), with occasional comparatively narrow bands of sandstone. Here, however, there is a sudden change to white quartzites, and

⁽¹⁰⁾ "Report on the Progress of the Stanley River Field," by A. Montgomery, 1895.

⁽¹¹⁾ "Report on the Prospects of the Stanley River Tinfield," by G. A. Waller, 1904.

only very occasionally are narrow bands of slate met with. The slates appear to have a more perfect slaty cleavage, and to be considerably more micaceous than the Dundas slates; no reddish varieties were seen.

The steep V-shaped valley of the Four-mile Creek (where the two series junction) suggests a fault-line, but the writer could find no definite evidence to support this theory.

Whereas the average strike of the Dundas slates is about N. 53° W., and the dip south at 75° , that of this series of quartzites and slates is apparently N. 66° W., with a dip north at 80° .

The two formations, then, are unconformable, and it would seem (though it is not certain) that these beds dip under the Pre-Silurians.

Lithologically, too, the specimens from this district closely resemble known Pre-Cambrians from other localities.

The relation of these beds to the Silurians developed round Zeehan has not yet been determined by the writer. As far west and south as they were explored, some 4 miles from the granite contact, they still showed intense alteration and crushing with silicification, and any original organic remains contained would be destroyed. This intense alteration would seem to point to the rocks being older than the comparatively soft, white, friable Silurian sandstones.

However, the possibility that they may be younger than the series to the north has been considered, and that they may even be Silurians intensely altered by contact and dynamic metamorphic agencies. The writer could obtain no evidence to support this view.

Again, the possibility that the series may be a continuation of the Pre-Silurian sediments has been considered, that the difference in composition may be more gradual than is supposed, and that the seeming disparity in dip may be due to the igneous intrusion. In this case they would be continuous with the Balfour slates and sandstones so largely developed in the Mt. Balfour field,⁽¹²⁾ and ascribed by Mr. Ward to Cambro-Ordovician age.

However, until further evidence is available, the writer prefers to regard them as being older, and to tentatively class the series as of Pre-Cambrian age.

The quartz veinlets cutting through the rocks in various directions would seem to be due to the granite intrusion,

(¹²) Geol. Surv. Tas. Bulletin, No. 10, pp. 31-37.

and to mark the latest phase of its consolidation. It must have been subsequent to the formation of the quartz tourmaline rocks described, for veinlets of white quartz cut through these, sharply interrupting the bands of quartz and tourmaline, and in some instances slightly faulting them. The quartz probably belongs to the hydrothermal stage of consolidation.

No ore-bodies have been located in this series, though it certainly is favourable. Some years ago a group of sections was taken up on the head of the Meredith River for "silver, copper, and associated minerals," but no work seems to have been done, and no information could be obtained as to the existence of any ore-body. In the same locality a group of 10-acre sections was previously held for gold, but no information is available of any gold having been won.

On the banks of the Stanley River some tin has been won from alluvial resting on these quartzites and slates. This has been derived from older river terraces now denuded, which evidently existed along the Stanley River.

Further to the north again, in streams heading from the Meredith Range granite, a little tin has been located in the alluvial derived from the granite by the ordinary processes of weathering.

(2)—*Pre-Silurian Slates, Sandstones, and Tuffs.*

A large portion of the district is occupied by a series of slates, sandstones, and tuffs, with apparently interbedded igneous rocks.

The basic and acid igneous masses of Devonian age already described have intruded these, and they are considerably altered for some distance from the contact. In fact, it is only beyond the boundaries of the tinfield proper that they assume their normal characteristics. Here they consist of reddish-purple, chocolate, or greenish slates, weathering to a brown clay. Coarser varieties are brownish.

Nearer the igneous mass the slates are converted to cherts and the sandstones to quartzites. The prevailing colour is bluish. In general they are unaltered by weathering agencies even near the surface, but where conditions have been specially favourable for ground water circulation, they have weathered to brownish clays.

The series is quite continuous with the series of slates and sandstones so typically developed at North Dundas. The main track from Renison Bell to the field gives one the opportunity of tracing this continuity.

Although consisting of slates in the main, with recognisable interbedded tuffs in some localities, there are also developed beds of sandstones.

In the bed of Four-mile Creek one or two small specimens of conglomerate similar to that occurring in the series in other localities were found, but a search failed to reveal this rock *in situ*. It doubtless occurs at a particular horizon in the series now hidden by the overburden of soil.

On the western slope of Mt. Lindsay spur, in the north-east corner of Section 5720-M, is an outcrop of a speckled rock, which proves to be a true breccia. It consists of angular and subangular fragments of white quartzite, with some darker fragments also, the size being even and of about 3 to 4 m.m. in diameter. These are imbedded in a finer groundmass, now cemented by silica. The rock is extremely hard, and silicified by the action of the granite. The accompanying sandstone, also *in situ* at this spot, is also much hardened, and breaks with perfect conchoidal fracture.

At no other point in the district was a similar breccia seen, nor could the extent of the band be traced lineally.

Although of different appearance, a rock of similar origin is that occurring in this series on the main pack-track from Renison Bell to the Stanley River at the mile-peg marking 7 miles from the Pieman River. It is exposed *in situ* in a small cutting made for the track. It is an excessively tough, hard rock of a dark chocolate purple colour, brown on the weathered surface and showing a curious roughness, hard lumps and nodules up to nearly 1 inch in diameter standing out as much as $\frac{3}{4}$ -inch from the general surface of the rock. These are due to aggregates of harder fragments in the rock resisting the attacks of weathering agencies much more strongly than the finer groundmass of the rock.

On a freshly-broken surface the rock is seen to be fragmental, and to be composed of angular and subangular fragments, mostly dark in colour, set in a fine groundmass, while abundantly scattered through the rock are rounded greenish-white crystalline aggregates, evidently zeolites. Although not always well marked, some specimens show a poorly-defined schistose structure.

The visible outcrop on the track is about a chain in width. At this point there is very thick undergrowth on either side of the track, and although a search was made on several occasions, no further outcrops could be discovered.

The rock is evidently a breccia, and would seem to be interbedded with the slates. The silicification and schistose structure have been caused by the same forces which have affected the surrounding slates, both (a) crustal folding, (b) the granite intrusion.

Within a few chains of the spot where the previously described breccia was found, one or two boulders were noticed of a rock unlike any other seen on the field. On account of their being a good deal weathered and traversed by numerous cracks, in many of which limonite had been deposited by percolating solutions, it was found impossible to obtain really fresh specimens of this rock, although a considerable quantity was broken up in the attempt. It consists apparently of angular fragments of quartzite in a siliceous cement, slightly mineralised.

At several points in the slate area, loose fragments of porphyroids were found, similar to those occurring so abundantly further east. In no case were these rocks observed *in situ* in the field, although they almost certainly do occur. The outcrops are hidden by the surface soil and luxuriant undergrowth which prevails.

With reference to the age of these sediments, no definite evidence is obtainable in this district. They are intruded by basic, intermediate, and acid igneous rocks, which are assumed to be of Devonian age.

Field observations show them to be continuous with the series developed at North Dundas, which have been judged to be of Pre-Silurian age, on evidence set forth in another place.⁽¹³⁾ The series presents a somewhat peculiar appearance at the Mt. Lindsay Mine, in a small side-cutting made for the pack-track. Here there is an outcrop about 1 chain across the line of strike. Although forming now a compact rock the original bedding-planes are distinctly shown. The average strike is N. 53° W., and dip south-west at about 75°. Of a general dark-blue colour, some of the bands are much lighter in colour, being shades of slaty-blue, greenish, greenish-grey, and grey, on fresh surfaces. They are very hard, and very compact, and nothing definite can be determined of the structure of the rock in hand specimens, even under the magnifying glass. The occurrence of some of these bands is very peculiar. They have the appearance of being intrusive bodies, for some of the bands are not continuous, the apparently intrusive bodies ending abruptly,

(13) Geol. Surv. Tas. Bulletin, No. 6, p. 33.

and themselves consisting of well-marked bands of particoloured material. This would seem to be due to a partial fusion and recrystallisation of the rock.

In places there are small veins of a greenish mineral cutting through the slates. A thin section shows this to be actinolite.

Even though indurated, and in some cases silicified, the rocks retain remarkably well their banded structure. Slight differences in the composition of the original sediments are still distinctly visible in the resultant cherts, although all may be now forming the one rock, so compact that in breaking off specimens from the junction of an original sandstone and slate band, the rock breaks across the bedding-plane of the two varieties. Since we are dealing with the modification the sedimentaries have undergone, as well as their unaltered forms, it will be well here to remark on the effect of the granite intrusion, *i.e.*, the nature of the contact metamorphic rocks. As is to be expected in the case of such an intrusion of acid rocks, the effects are very marked, for, as has been noted elsewhere in this report, the contact-metamorphic effects are caused not only by (a) heat and (b) pressure, although these elements exert an enormous effect, but also by (c) the effect of vapours and solutions released from the solidifying mass, which exert a considerable effect upon the rocks into which they are forced.

In the Pre-Silurian rocks the contact-metamorphic aureole is from 1 to $1\frac{1}{2}$ mile in width, measured from the exposed granite contact. This must be interpreted as meaning that the granite contact line dips at a comparatively flat angle below the series. This fact has an important economic bearing, for it considerably increases the area of rocks which must be considered as likely to reward the prospector, *i.e.*, which is likely to carry tin lodes. The whole of the contact-metamorphic belt is worth prospecting.

These contact rocks are hard, bluish, cherty rocks, varying somewhat in appearance according to the nature of the original sedimentary.

The first noticeable change in the slates is the development, as much as $1\frac{1}{2}$ mile from the contact in exceptional cases, of spotted slates: examined with a pocket lens dark spots are visible in the otherwise homogeneous material. Microscopically these are seen to be aggregates of the carbonaceous material of the sediment. Nearer the granite these spots become more marked; a slight schistose

structure is noticeable in a few cases. Flakes of biotite are developed, and a little quartz (and probably albite) is noticeable under the microscope in the groundmass.

In some bands white irregular-shaped fragments were noticed, giving the rock somewhat the appearance of a breccia. Microscopically little definite information is obtainable, as these masses are semi-opaque. However, there is little doubt in the writer's mind but that they really represent segregations of some constituents of the original sediment under the influence of heat, and that they resemble andalusite. In the groundmass are blades of actinolite.

Closer to the contact actinolite is abundantly developed; also biotite, quartz, and albite. Sillimanite also makes its appearance, and gradually the rock loses its sedimentary structure altogether, and under the microscope is seen to be composed entirely of recrystallised products. Until the nature of these minerals is realised, the rock has quite the appearance of being an igneous rock. Sericite and chlorite are sometimes developed.

Original sandstones are not so readily altered. In some cases the nature of the rock can still be readily recognised, although in the groundmass biotite and actinolite are developed.

One specimen was obtained from the New's Creek inlet on the Stanley Reward race, showing the actual contact of granite and slate. A thin section across the line of contact shows that the granite consists of orthoclase, quartz, plagioclase (not sufficient present to determine), and biotite. It is holocrystalline, and of a granitoid structure. The original slate rock is now composed of brown biotite, quartz, albite, and magnetite.

The variety of contact rocks is so great that no more than a general description of their chief characteristics, as revealed by a microscopical study, can be attempted.

The great variation in rocks taken from within a few inches of each other shows clearly that the composition of the original sedimentary rock has been the main factor determining its behaviour when subjected to these contact-metamorphic conditions of heat and pressure.

(3)—*Pre-Devonian Dolomite.*

Exposed in the bottom of the Stanley Reward alluvial workings is a somewhat unexpected development of white crystalline dolomite. At no point was the dolomite

observed to outcrop at the surface, and its presence was not suspected until sluicing revealed its presence beneath the button-grass flats. It forms the true bottom on which the wash rests in the southern portion of the section.

The occurrence was noted by Mr. Montgomery ⁽¹⁴⁾ in his report of 1895 in the following terms:—"Towards the south-west angle of Section 1940-91M (now 133-M), a shallow hole through the wash has bottomed on white granular limestone, possibly a result of alteration of the blue Silurian limestone seen elsewhere in the district, by contact with the intrusive granite."

With reference to the "blue Silurian limestone," Mr. Montgomery states:—"In going to these (*i.e.*, New's lodes, on New's Creek), a belt of blue limestone country is passed over, and at some old workings known as Stubbings', in the creek, the contact of this with the granite is seen, and it is clear that the latter is intrusive through the limestone."

Unfortunately, at the time of the writer's visit to the field, "Stubbings' workings" could not be located. Being "old" in 1895, they would seem to have been forgotten in 1912. However, the country in the vicinity of New's Creek was traversed several times by the writer, and examined as carefully as was possible in country covered in many places with almost impenetrable undergrowth. Particular care was taken in plotting the granite boundary with as much accuracy as possible. In spite of this examination no limestone was seen. The rock is hard blue slate and sandstone, altered by the granite intrusion, but quite similar to that in other parts of the district in the vicinity of the igneous contact. The actual contact of granite with slate was seen at several points along New's Creek, and thin sections examined of actual contact rocks, but nothing was seen to indicate that the rock was an altered limestone.

The point it is desired to emphasise is that *the white crystalline dolomite disclosed in the Stanley Reward workings cannot be correlated with any other occurrence in the district*. The nearest known limestone is that outcropping in the bed of the Wilson River near its junction with the Harman,⁽¹⁵⁾ which is blue limestone of Silurian age.

The dolomite on its upper exposed surface is pure white, and consists of a semi-coherent mass of fine grains, which

(14) "Report on the Progress of the Mineral Fields in the Neighbourhood of Zeehan," by A. Montgomery, 1895, p. xxxi.

(15) *Vide* Plate II.

may readily be crumbled between the fingers. It closely resembles a very soft friable sandstone. The unweathered rock is tough, and generally pure white and of crystalline structure. It varies, however, from point to point, and is sometimes of a general dark colour from inclusions, or has in places a banded structure, with dark bands containing magnetite. Light-green inclusions were noticed in places scattered through the white granular groundmass.

A thin section examined microscopically shows that the general structure of the rock is a mosaic of granular dolomite with scattered aggregates of serpentine, evidently pseudomorphs after olivine. In a few individuals remnants of olivine are distinguishable. In one case typical mesh structure is developed, remnants of olivine being enclosed in meshes of serpentine. It is evident that serpentinisation of the olivine has proceeded along the cracks, the increase in volume due to hydration causing fresh cracks to form, along which in turn the alteration has proceeded. The final result of the process is that the olivine crystal is completely converted to serpentine. When the process is arrested before the final stages are complete residual olivine grains are seen, and give the clue to the alteration which has taken place.

Magnetite is present in the slides examined—(a) in scattered crystals through the granular dolomite, (b) in the serpentine aggregates as minute disseminated grains, (c) in the serpentine marking cleavage-planes of the original olivine, (d) as borders to the serpentine aggregates.

The exact determination of the boundaries of the dolomite is still impossible, but from known occurrences, and known extensions of the surrounding rocks, it would seem to occupy an area of about 30 acres.

It is not only in contact with the granite on the north-western edge, in Section 133-m, but is intruded by the granite at more than one point.

At one spot was an occurrence apparently of granite-porphyry, intrusive into the dolomite. The outcrop had been bared by sluicing operations, but was covered by stacked heaps of boulders at the time of my examination. A microscopical examination of samples obtained shows that the rock is really a fine-grained biotite granite, of quite normal features, rather than a granite porphyry, as it appears in hand specimens. This fine granite shows dark coloured basic segregations in places.

The writer was informed that this outcrop was about 30 feet across when exposed. It was bordered by a

development of magnetite, said to be between 8 and 9 feet in width. The magnetite is both massive and in scattered crystals and crystal aggregates, in an altered dolomitic groundmass, which seems to merge into dolomite with disseminated magnetite.

About 60 feet north-west from this outcrop was another similar occurrence of fine-grained granite with a magnetite selvage, but intruded by a fairly coarse pegmatitic vein, varying considerably from point to point. Typically of coarsely crystalline quartz and orthoclase, crystals of phlogopite mica are developed in certain portions, up to 1 inch in diameter, while in other varieties black tourmaline makes its appearance. A thin section cut from portion of this intrusion showed orthoclase feldspar, quartz, and microcline feldspar. No mica is present in the slide. The structure is porphyritic, with phenocrysts of orthoclase. The groundmass is granulitic with smaller crystals of both quartz and orthoclase. Some of the quartz has crystallised out early, being included in many cases in the orthoclase phenocrysts. Some of the quartz is later, being moulded on the hypidiomorphic orthoclase, with a little microcline as the final consolidation product. There is noticeable a graphic intergrowth of quartz and feldspar in the groundmass, giving rise to the structure known as micropegmatite. The feldspar is slightly clouded by decomposition products.

At intervals throughout the exposed area of dolomite, minute fissures up to about $\frac{1}{8}$ -inch were noticed, filled with quartz. As the softer dolomite weathers, these veinlets break off, and form residual flakes which often resemble fragments of shells. These are abundant through the clay pug which overlies the dolomite in many places. Cutting across the dolomite about the centre of the paddock worked on the western bank of the river at the time of my examination was a well-defined fissure striking due north and south, filled with quartz crystals and chalcedonic silica; the silicified belt is about 10 feet wide.

It comprises numerous geodes of various sizes and shapes, containing linings generally of quartz crystals, sometimes of chalcedony, and connected by bands and stringers of crystalline quartz.

The quartz crystals are never large, but form beautiful specimens, being perfectly transparent, and varying in size from microscopic dimensions up to about 4 millimetres across in section, by about 8 m.m. long. Prismatic and terminal pyramidal faces are always developed, even on the individuals of microscopic size. The fantastic form

of many of these masses of crystals suggests that may be deposited on stalactitic chalcedony. The latter does occur both in nodular and stalactitic forms in some geodes. The size varies considerably, geodes from a fraction of an inch up to about 2 feet across being noticed. In shape, too, there is a wonderful variety. While many approach more or less nearly the sphere, others are in pipe-like forms. Specimens were seen of geodes over a foot in length and of triangular section, lined completely with quartz crystals. Some rather curious forms were noticed. The crystals lining a geode were sometimes covered and hidden by a mass of opaque white thread-like forms of microscopic diameter. These white threads intersect each other at all angles, and often extend across from side to side of a geode. They were rather puzzling, but the microscope showed that they were composed of quartz; and further, the high power showed that the apparent "threads" are really strings of individual quartz crystals, of extremely minute size, connected one with the other. The crystals are doubly terminated, and lie generally parallel, the prism faces usually at right angles to the length of the "thread," and the pyramids projecting on either side, while the joining of prism faces of adjoining crystals formed the connected string. These crystals were not measured, but the length (*i.e.* diameter of "thread") would probably be considerably less than 0.1 millimetre.

A noticeable feature in several of the specimens collected from this interesting spot, was the abundance of "negative crystals." Preserved in silica (sometimes chalcedonic) are numerous impressions of crystals now removed, but whose form suggests that some rhombohedral carbonate has been present. In nearly all cases it was noticed that the quartz containing these impressions was a crystalline structure when broken. Many of these showed with walls about $\frac{1}{2}$ to 1 inch thick, would be encrusted with perfect quartz crystals on the convex side, while the concave side was a mass of impressions as described. The inference is that crystals of some rhombohedral carbonate were present originally, and on these the silica was deposited. They thus formed the foundations for the geodes, and at some period subsequent to the deposition and crystallisation of the silica, the original substance was completely removed, although the casts of the crystals are so perfectly preserved. Scattered crystals of pyrite were

noticed in several instances embedded in the "faces" of these casts; sometimes also in aggregates in the walls of the geodes, or in crystals in minute fissures through those walls, but pyrite was not noticed in the geodes themselves.

Disseminated pyrite was observed in many places in the exposed dolomite; also as a filling of minute fissures intersecting at various angles, and as crystal aggregates in various places.

Abundant pieces of pyrite (in aggregates of cubical crystals), of pyrite and pyrrhotite, of galena and blende, and of pyrite, galena, and blende, were picked up in sluicing, and were particularly abundant in certain definite localities. Here they were found, too, embedded in the clay pug which covers the dolomite.

The writer is of opinion that definite lodes will be found to occur here in the dolomite. No prospecting has been done, and hence little can be said as to the occurrence, but it appears that at least two lodes will be found *in situ* here, one essentially pyritic, the other of pyrite-blende-galena.

Reference has been made to this occurrence in another part of this report.⁽¹⁶⁾

The stiff clay "pug" which covers the dolomite has been described and discussed elsewhere in this report.⁽¹⁷⁾

It is believed by the writer to be a decomposition product of the dolomite, which is shown to be impure.

One other feature, and it is believed rather an unusual one, remains to be discussed, viz., the occurrence of asbestos in the dolomite. It was noticed first in the "pug" in scattered shreds, and was afterwards definitely located *in situ*, filling narrow seams in the dolomite. I was informed by Mr. Albury that he had seen seams up to 2 inches in thickness in the dolomite.

The largest specimens obtained by the writer were plates $\frac{3}{4}$ -inch in thickness and 9 inches in length.

In no cases noticed were the fibres crossing the veins at right-angles; they were always longitudinally in the fissures. The asbestos has a bronze tint generally on the surface, but unfortunately all specimens seen were from the weathered dolomite. On stripping off the outer layer of fibres, the fresh material is seen to be white and silky, and is separable into very fine fibres, which do not readily break across, and are certainly not brittle. As occurring in the

⁽¹⁶⁾ *Vidr* page 101.

⁽¹⁷⁾ *Vidr* page 132.

weathered portion of the dolomite the material very closely resembles decaying wood fibre, and the material disseminated through the "pug" above the dolomite was mistaken at first sight for wood. These fragments seemed much decomposed, being very soft and possessing no strength whatever.

The material is infusible before the blowpipe. It yields a little water in the closed tube, blackening after being heated to a fairly high temperature. The specific gravity of the freshest material obtainable was 1.54. It was attacked on boiling with hydrochloric acid for some time, the residual fibres having little strength or coherent power, and apparently consisting mainly of silica. Nitric acid had less effect, a certain amount of iron going into solution, perhaps from contained impurities. Some action was apparent on treating with strong sulphuric acid, both solution and fibres darkening considerably, but on washing and drying, the fibre was bleached, and its tenacity small.

It is a matter for regret that no analysis of the material is available. Until such is available the final explanation of the material must be postponed.

The presence of olivine and serpentine in the dolomite, and certain of the properties, suggest that it may be chrysotile. The writer is more inclined to the opinion that it is really asbestos, a fibrous variety of amphibole. The specific gravity is high for the "mountain cork" variety, but very low for chrysotile. Unfortunately, however, we are not dealing with absolutely pure and fresh material, and impurities may account for the discrepancy.

Although of considerable mineralogical interest this occurrence of asbestos is not likely to be of any economic value.

The Mode of Origin and Age of the Dolomite.—The occurrence having been fully described, it remains to refer briefly to the probable mode of origin and age of the dolomite.

It must be admitted that the occurrence is a puzzling one, and the writer is not able to fully explain it to his own satisfaction.

Can the deposit be formed as a direct result of precipitation from magmatic waters? This does not seem likely. The shape of the deposit, regarded in plan, is peculiar, being approximately circular, so far as is known, but further prospecting of the locality may prove the extent to be greater, and bring to light facts with regard to the relation of the dolomite to the sedimentary rocks

of the neighbourhood which would assist in elucidating the problem. Dolomite has been recognised in at least one ore-body in the district (Mt. Lindsay), and is there assumed to be deposited from solution. But it occurs there in quite negligible quantities, compared with the present case. Since no rocks are known here which could have yielded such a large amount of lime and magnesia to magmatic waters, this theory does not seem feasible; as the dolomite is so near the granite it seems that practically the whole of the lime and magnesia content would have been supplied from the magma, if such were the mode of origin, and this assumption scarcely seems a legitimate one to make.

Another serious objection occurs to the writer. It is hardly conceivable that even were the solutions supplied with their lime and magnesia content from the magma or from the traversed rocks, or from both, that a body of carbonates could have been produced, in contact with the mass of molten rock, at such an early stage, before solidification of the granite took place, for the dolomite must have been formed before the solidification of the granite, since the latter has intruded and altered it.

Although there is no direct evidence to show that such exists among the neighbouring country-rocks, the writer is of opinion that a bed of limestone existed, and that the intrusion of the granite mass has altered it, and rendered it crystalline. An analysis of the dolomite, showing the amounts of calcium and magnesium carbonates present, would be of assistance in explaining the probable mode of origin, but such is not available. It is now recognised that a high temperature is not necessary for dolomitisation to take place, and this change may have been induced in a magnesian limestone, before the igneous intrusion took place, but this matter cannot now be definitely determined. The development of olivine (which is the variety called forsterite) is to be attributed to the metamorphic effects of the granite intrusion. The magnetite noted in connection with the granite actually intruding the dolomite is doubtless derived (in part, at least) from the iron content of the dolomite. It is not unlikely that the original limestone was ferriferous.

The structure and composition suggests that the rock is akin to the opicalcites.

With reference to the age of the formation, all that can be stated is that it is Pre-Devonian. The fact that granitic rocks of known Devonian age have intruded it,

and altered it at the contact, puts this fact beyond doubt. The occurrence of sulphides of iron, lead, and zinc, and also the development of crystalline quartz already described, are all derived from the same intrusive magma, and even apart from the actual occurrences of granite itself, the presence of these minerals points definitely to the age of the dolomite being Pre-Devonian.

Whether it belongs to the Dundas slate series, of Pre-Silurian age, or to the series of quartzites and slates lying further to the west, is a matter which cannot be decided at present. The writer's doubts as to the true age of the latter series, which have been called possible Pre-Cambrians, are grave. It may be that this series is younger, and that the limestone is to be classed with that group of sedimentary rocks.

It is because an original sedimentary origin has been assumed for the dolomite that it has been included under the heading of the sedimentary rocks.

(4)—*Silurian Sandstones, Slates, and Limestones.*

To the east of the Wilson River, and intruded by the basic rocks already referred to,⁽¹⁸⁾ is another series of sedimentaries, noticeably different from those between the Harman and Stanley Rivers. The Wilson River has cut its valley for some distance along the boundary between this series and the gabbro. Consisting of white sandstones, somewhat soft and friable where exposed to weathering agencies, soft blue slates, and compact dark blue limestones, an examination shows that marine fossils are represented in each variety.

The sandstones at the points visited did not appear to carry very abundant fossil remains, nor did the limestones. The slates, however, showed fairly abundant well-preserved forms.

The series is undoubtedly of Silurian age.

The general strike of the beds appears to be east and west, varying at different points from about N. 80° E. to S. 80° E. The dip is south at about 60°.

The only points in this series visited by the writer were adjacent to the igneous intrusion of gabbro, as the Silurians only appeared on the extreme edge of the district, and in consequence of this intrusive mass it is possible that strikes and dips as noted may not represent the true figures relating to the beds in their normal condition.

(18) *Vide* page 18.

The members of this series extend for some distance eastward—how far is not yet known, although the writer was informed by prospectors on the field that the same country continued east for several miles.

The Mt. Merton Mine, described later, is situated on this series.

Among the determinate fossil remains, *Orthis* and *Rhynchonella borealis* were recognised in the sandstones, together with remnants of *Orthoceras* and indefinite discoidal impressions abundantly represented in some beds.

In the soft blue slates are abundant impressions of *Tentaculites* and *Rhynchonella borealis*.

Although informed that fossils had been found in the limestone, none were discovered at any point visited. Outcrops were found to be scarce, being mostly hidden in the dense undergrowth.

In the bed of the Wilson River, a few chains north of its junction with the Harman, is a development of compact blue limestone. It occurs as a bar crossing the river, and also on the eastern bank, but is mostly hidden by the dense undergrowth which prevails at this point.

The modification of the Silurians by contact with the basic igneous rocks is slight. They are hardened and silicified, and the sandstones converted to quartzites, but this change seems to have been very local, and not to have extended many yards from the igneous rock.

This belt of rocks may prove to be of considerable economic importance as prospecting proceeds.

Tin is known to occur both *in situ* and as a residual alluvial deposit at Mt. Merton.

Alluvial gold has been found, though not in very large quantities, in some of the creeks flowing into the Wilson River. Prospecting may locate the source of this gold. It will probably prove to occur in the Silurian rocks.

In creeks in this portion of the district osmiridium has been located, and successfully worked by small parties of men. The osmiridium is not derived from the Silurian rocks. The creeks referred to all head from serpentine country to the west, and it is here that the true home of this much-sought metal is. The slates form particularly good riffles for the metal, which lodges in the crevices. In practice the slate is generally picked up from the creek bed to a depth of 12 to 18 inches, and carefully washed to obtain mechanically included osmiridium, which works down to a considerable depth in the cleavage cracks of the beds of slate.

Narrow veins of galena and of pyrite were noticed in the Silurian sandstones at the Mt. Merton Mine.

The sequence of the beds developed is not very evident, field evidence being largely obscured by cover of button-grass and vegetation.

The lignite referred to later, as occurring at the Mt. Merton Mine,⁽¹⁹⁾ is peculiar in occurrence and mode of origin, and needs further explanation. The material resembles brittle, bright, black bituminous coal in appearance, but has been called a lignite for reasons given later. Coal is not known in strata as old as Silurian,⁽²⁰⁾ while lignite is developed chiefly in the Tertiary. Nor has the writer heard before of the association of lignite with cassiterite *in situ*. The lignite occurs in narrow seams which vary somewhat in width from point to point, up to 2 inches. Frequently veinlets of $\frac{1}{8}$ to $\frac{1}{4}$ inch are seen running through the sandstones, the fissures corresponding in strike and dip with the enclosing strata. Where it occurs, the zones of sandstone seem much shattered, and therefore very porous.

This occurrence of lignite in Silurian strata is of peculiar interest, and is at first sight puzzling; it is of no commercial value. In colour it is bright black with a good lustre; it is soft, and the streak is brown. The specific gravity (mean of six determinations) is 1.49. Some of the material was submitted to the Government Analyst, Mr. W. F. Ward, for analysis, who reported as follows:—

“ Fixed carbon	36.9 per cent.
Ash	7.2 per cent.
Gases, &c., lost at red heat ...	38.4 per cent.
Water lost at 212° F.	17.5 per cent.

“ The above figures were obtained by testing selected pieces . . . The black particles gave a brown powder which remained powdery on heating. The gases were similar in smell to those given off by some lignites.”

There can be little doubt, then, that the material is really a variety of lignite.

One feature noticed in connection with the occurrence was the presence of pyrite in the heart of fragments of lignite. Another fact worthy of note was the presence of small spherical nodules of about $\frac{1}{4}$ -inch diameter. The specific gravity of these was found to be 3.04. Although

⁽¹⁹⁾ *Vide* page 171.

⁽²⁰⁾ *Vide* “The Geology of Coal and Coal-mining,” by W. Gibson (1908), p. 42.

fairly hard and smooth on the surface, they were found to be soft and earthy internally. These appear to be concretions formed from infiltrating solutions.

It was noticed that where the seams of lignite occurred the country-rock was quite black, being saturated with carbonaceous material; the lignite itself was sometimes brown and earthy, and at other times, when filling fissures, jet black. The lignite occurs wherever underground work has been done on the formation, the deepest point being about 60 feet below the surface.

The occurrence of lignite in Silurian rocks is unusual, and needs an explanation. In the writer's opinion it is a carbonaceous deposit from surface infiltrating solutions, and not a true lignite. It shows no woody structure. The fact that all these lignite-bearing zones were very wet was striking, a large amount of water finding its way into the porous zones. The surface of the hill is clothed by a thick vegetable cover, beneath which is a considerable thickness of very porous detrital matter. The writer believes that organic matter has been introduced by surface waters soaking through these layers.

Since writing the above the writer's attention has been drawn to two papers dealing with occurrences of carbonaceous material in Silurian sandstones.

At the Hobart meeting of the Australian Association for the Advancement of Science, 1892, Messrs. A. Montgomery (then Government Geologist) and W. F. Ward (Government Analyst) read a paper entitled "Notes on a Carbonaceous Deposit in Silurian Strata at Beaconsfield, Tasmania." They refer to abundant lignitic material occurring in very much shattered beds, in the workings of the Tasmania and Moonlight mines. These beds are of Silurian age, and consist of sandstones and grits. The carbonaceous matter occurred, not only in the beds of grit (where it was sometimes found coating "sharp angular stones of grit"), but also penetrating cracks and joints, where it was brighter and purer than elsewhere. It occurred in the 422-feet level from the Moonlight Company's shaft.

The authors state: "We find it comes nearer to lignite or brown coal than to anything else. It is from brownish-black to pitch-black in colour, soft, pulverulent and earthy to coherent and brightly lustrous, with brownish dark streak, and specific gravity slightly greater than that of water. Much of it has a finely-banded structure, alternate layers being bright black and brownish earthy, slightly suggesting a woody structure at a first glance.

The average composition was found by analysis to be as follows:—

	Per cent.
Carbon	38·91
Hydrogen	3·03
Oxygen and Nitrogen by difference	21·60
Sulphur	2·36
Ash	12·00
Moisture lost at 100° C.	22·10
	<hr/> 100·00 "

The authors are convinced that this carbonaceous material is really a variety of brown coal of probably Tertiary age, formed by the deposition of "peaty substance," from surface swamp waters percolating into this shattered and porous belt of country.

This occurrence bears a strong resemblance to that at Mt. Merton. Not only is the actual occurrence similar, but the physical and chemical properties of the material are obviously similar also. It is interesting to compare the above analysis with that made by Mr. Ward of the Mt. Merton material, and to see how closely the two correspond.

In 1902 Mr. W. H. Twelvetrees, Government Geologist, issued a "Report on Deep-sinking at the Moonlight-cum-Wonder Gold Mine, Beaconsfield."

Mr. Twelvetrees⁽²¹⁾ says: "In the Eureka claim . . . recent timber was found in the drive, 370 feet below the surface, associated with boulders of conglomerate. Mr. Heerey informed me that a large log of this timber, 3 to 4 feet in diameter, had to be cut with an axe; this semi-lignitic deposit extended for 40 feet. He also states that in Sam. Statton's find, at a depth of 132 feet, several years ago the miners while at work heard a noise as if the shaft were coming together, and found that two fissures 6 to 8 inches wide and 3 feet apart had opened in the conglomerate. In Messrs. Montgomery and Ward's paper, referred to above, a deposit of brown coal is described as occurring in the Tasmania and Moonlight workings at a depth of 422 feet in the latter mine, introduced from surface into the broken rock-formation. The crosscut north, after intersecting the pug formation,

(21) Page 8

entered grits veined with calcite, and its present end is in grey limestone Behind the end the crosscut passed through a peculiar brown earthy carbonaceous deposit, approaching in character to semi-lignite or brown coal. It is 9 feet wide on the west side of the drive, but is represented on the east side by only a couple of narrow seams a few inches thick. Despite the compact bedded appearance of the deposit, I am of opinion that it is the result of percolation from the surface, subsequent to the laying down of the Silurian strata. It may be compared with the occurrences mentioned by Messrs. Ward and Montgomery. A sample has been analysed by Mr. W. F. Ward, with the following result:—

	Per cent.
Fixed carbon	13·9
Gases, &c., lost at red heat ...	27·0
Mineral matter (ash)	21·0
Moisture lost at 212° F.	38·1
	<hr/>
	100·00 "
	<hr/>

It is interesting to note that the occurrences at Beaconsfield have been assumed to have a mode of origin exactly similar to that which the writer postulated for the Mt. Merton occurrence before seeing the two papers referred to.

The Mt. Merton occurrence is possibly also of Tertiary age, although no evidence was available to determine this point.

(5)—*The Older River Gravels of Pleistocene Age.*

In dealing with the physiography of the district, reference has already been made to gravels at a considerable height above present river systems.

To the extreme south-east of the area mapped, on the main track, gravels were noted on the southern bank of the Pieman, before reaching the suspension bridge. These are found to be 320 feet above sea-level, and in the section exposed by the cutting for the track appear to be about 40 feet deep. On the northern bank of the Pieman, and a short distance east of the Wilson River, gravels are again exposed on the new track to Mt. Merton and the surrounding district. As determined by aneroid readings, the height of these gravels is about 315 feet above sea-level.

The Pieman River here is about 160 feet above sea-level (height below bridge not exactly determined).

Along the banks of the Wilson, on the track between the Pieman suspension bridge and the 4-mile peg, wash was noted in several places, the height above sea-level averaging about 320 feet.

At another point higher up the Wilson, above its junction with the Harman, beds of gravel were noticed about 15 feet above the present river-level, and about 340 feet above sea-level.

Between the Wilson and Harman Rivers, at their confluence, is a somewhat extensive belt of alluvial with river gravels. The highest point at which this was noticed was 390 feet above sea-level.

In all occurrences along the Pieman the gravels appear to be of somewhat similar composition—quartz, quartzites, porphyroids, and quartz-tourmaline. The source of these pebbles, in the case of the Pieman gravels, is doubtless to be found in the West Coast Range. Exactly similar occurrences have been noted by Mr. L. K. Ward in the North Dundas Tinfield.⁽²²⁾ Unlike that occurrence, however, no large boulders were noticed in the Stanley River district.

The pebbles of the Wilson River gravel beds are not derived from any formation at present exposed in the district examined. Whether denudation has removed all traces of the parent beds, or whether such exist at some point in the upper course of the river, cannot be definitely determined.

The gravels carry a little disseminated tin, also some chromite. A little gold found in creeks cutting through the gravels has also doubtless been derived from them.

Along the Stanley River and some of its tributary creeks the gravels become of great economic importance on account of the contained tin. The wash has been worked along the Stanley River, Livingstone Creek, New's Creek, Castle's Creek, and Minor's Creek.

The nature of the wash is dealt with more fully later on.⁽²³⁾

Corrected aneroid readings show that the flat now being worked at the Stanley Reward is about 690 feet above sea-level, remnants of older terraces being found at 740 feet above sea-level, and 50 feet above present level of the Stanley River.

⁽²²⁾ *Op. cit.*, page 35.

⁽²³⁾ *Vide* page 131.

From the nature of the wash it is very evident that its derivation is not far to seek. The granite facies of the Meredith Range massif have contributed more largely than any other formation, though schists from the west, and porphyroid and slate from the east, have added their quota. The pebbles are generally well rounded.

No evidence to fix the age of these gravel deposits is obtainable on the field. In the North Dundas district, however, Mr. Ward⁽²⁴⁾ has inferred from the presence of huge erratics of conglomerate and porphyroid imbedded in the wash, that the age is approximately Pleistocene. As the gravels in the Stanley River district are certainly contemporaneous with those at North Dundas, and, in fact, form part of the same series, these gravels are referred also to Pleistocene age.

(6)—*The Recent Alluvial Deposits.*

As has been pointed out, base-levelling is still in progress in the district, and consequently no important depositions of alluvial are taking place at the present time. At points along the Stanley and Wilson a little recent debris has accumulated, but none of any extent or probable importance were noticed. The material is partly well-rounded, and partly sub-angular, the former being derived from the older river terraces, the latter from the effect of weathering agencies at present at work.

One recent deposit worthy of some attention is that at the junction of Tulloch and Four-mile creeks. Tulloch Creek cuts through the Mt. Lindsay ore-body, and this flat (though not of large extent) forms the first catchment for any tin ore shed from the formation, the bed of the creek being too steeply graded to afford any catchment above this point.

Other recent deposits of small extent occur in places throughout the district.

C.—THE GENERAL SEQUENCE OF EVENTS LEADING TO THE PRESENT GEOLOGICAL STRUCTURE.

The general geological history which has resulted in the present structure will here be briefly described, summarising to some extent what has already been described in further detail under separate headings.

(1) *The First Period of Sedimentation.*—On a floor not now discernible, in Pre-Cambrian times, a thick series of sedimentary rocks was laid down, mainly under shallow-

(24) *Op cit.*, p 36.

water conditions, although alternating at times with deep-water conditions. Sedimentation must have continued over a long period, probably followed by—

(2) *A Period of Diastrophism*.—There is no very direct evidence of this phase, but it is probable that the sediments already formed were not only tilted, but modified in structure by the earth movements which took place.

(3) *The Second Period of Sedimentation*.—There now followed another long-continued period of sedimentation when in this district deep-water conditions seem to have prevailed. There were, however, times of uplift, when the sediments were formed in shallow waters. An immense thickness of strata was formed at this time, represented now by the extensive Dundas slate series. Towards the close of this sedimentation there are evidences of—

(4) *A Period of Vulcanism*.—From occurrences in other districts rather than from the facts presented by this field we know that both intrusive and extrusive processes were active. Igneous rocks were forced up into the sediments already formed, as well as fragmental types being interbedded with the final members of the sedimentary rocks.⁽²⁵⁾

(5) *Folding of the Region in Pre-Silurian Times*.—A comparatively short time-period must have elapsed between the close of the first period of vulcanism and the second period of diastrophism, which resulted in the rocks previously formed being intensely crushed and altered. It was at this period that the well-marked fissile structure of the Dundas slates was developed.

(6) *Third Period of Sedimentation*.—After probably a considerable time-break, a third period of sedimentation set in, when marine conditions prevailed, and the sedimentary rocks developed in the eastern area of the district were formed. This was in Silurian time. During this time, too, deep and shallow water conditions seem to have alternated. Enclosed in the sediments and preserved by them are relics of the animal life which existed in this Silurian ocean.

This period of comparative tranquillity was succeeded by—

(7) *A Second Period of Igneous Activity*.—In Devonian time, and not following immediately on the previous sedimentation, there was introduced a great mass of igneous material. This was forced up into the overlying strata,

⁽²⁵⁾ Although not observed *in situ*, fragments of porphyroid and clastoporphyroid were found throughout the district.

but still deep below the surface, differentiation took place. The more basic portion was forced up along a zone of weakness, probably never reaching the surface, although rising to different heights. This was followed by further intrusions of material of intermediate composition at isolated points, and finally the acidic portion of the original magma, of enormous bulk, was intruded into the overlying rocks, bulging and shattering them, and causing considerable alteration in them. It was at this time that the primary ore-bodies of the district were formed. The genesis of the deposits is dealt with in another part of this report.⁽²⁶⁾

This period of intense igneous activity was followed by—

(8) *A Period of Gradation.*—The forces operative at this time must have continued over a very long period. We have no record of any rocks being formed in the district since the Devonian igneous activity finally ceased, excepting the limited areas of partly consolidated or quite unconsolidated gravel. During the period processes of degradation were constantly at work, levelling down the uneven surface. The hills were worn down, and an extensive plain, gently sloping seawards, was formed, although some of the higher peaks still stood out as islands above this general level. With the rest of the land surface, the river beds were worn down, until finally the gradient became too flat to allow of the load of detrital matter, composed of rock waste, being carried to the sea. Hence this material was deposited over the flood-plains gradually developed. The cover of sedimentary rocks which had originally protected the igneous rocks was removed, and the streams cut deep down into the igneous rocks themselves. It was during this period that the secondary ore-deposits were formed.

(9) *Period of Uplift.*—There is clear evidence that the long period of gradation was followed by a period of uplift.

The rejuvenated streams proceeded to cut through the alluvial deposits already formed, and with their beds once more steeply graded, to reduce the surface again to a common base-level. It is clear that this movement has not been one simple uplift, but the terraces on the river-banks indicate that on several occasions base-level has been reached, followed again by a further uplift.

At the present time the streams are once more engaged in deepening their channels, and degrading the land surface.

(²⁶) *Vide* page 121.

V.—ECONOMIC GEOLOGY.

(1)—GENERAL RELATIONSHIPS OF THE ORE-DEPOSITS.

In his bulletin on the North Dundas Tinfield (²⁷) Mr. Ward has pointed out how constant is the occurrence of acidic igneous rocks with the ores in the tinfields of the West Coast, although the exact acidic type represented is not always the same.

At North Dundas we have granite-porphyry and quartz-porphyry.

At Zeehan, quartz-porphyry.

At Heemskirk, granite and granite-porphyry.

At Mt. Bischoff, granite-porphyry.

At Granite Tor, granite.

At Interview River, granite.

At Middlesex, granite and granite-porphyry.

It is now clearly established that this association is not merely accidental, but that the ore-deposits and acid rocks are genetically connected.

Both in the fact that the tin lodes are closely associated with acid igneous rocks, and that they are genetically connected with them, the Stanley River Field closely resembles those already mentioned. As has been already pointed out, the ore-bodies occur near the junction of intrusive granite with older sedimentary rocks, partly in the igneous, partly in the sedimentary rocks, and associated with both granite and granite-porphyry.

The presence of a formation of the pyritic lead type, carrying silver, lead, and zinc, forms a connecting link with other fields.

The gangue minerals point conclusively to the granitic magma as the source of the ore-bodies.

Here, as has already been pointed out, the association of basic rocks with the acid group forms another connecting link with the tinfield of North Dundas. These rocks are not only genetically connected themselves, but connected also with the ores.

(2) RELATIONSHIPS OF THE ORE-BODIES TO THE SEVERAL ROCK TYPES.

A glance at the accompanying geological map of the district (²⁸) will show that the ore-bodies occur in totally different geological formations, although never very far from the granite.

(²⁷) Geol. Surv. Bull. No. 6, pp. 40-43.

(²⁸) Plate II.

The Mt. Lindsay ore-body is situated entirely within the boundaries of the Pre-Silurian sediments, so far as is known at present; it has been traced to within a few chains of the contact with the granite, but the actual contact is hidden by dense undergrowth which has not been disturbed by prospecting operations. From its mode of origin, the ore-body may be continuous in the granite, but such has not yet been proved.

Situated in sedimentary rocks of decidedly younger age than the preceding, *i.e.*, fossiliferous Silurian strata, is the Mt. Merton ore-body, in close association with basic rocks.

At the junction of the granite with the Pre-Silurian rocks is the Stanley Reward ore-body. It would seem to be bounded by granite and by the sedimentaries referred to.

Well within the borders of the granite are several quartz-tourmaline-cassiterite veins, of which Castle's lode may be taken as the type.

So that ore-deposits occur indiscriminately in the intrusive granite and in the sedimentary rocks which it has intruded.

The ore-deposits of the Stanley River Tinfield fall naturally into two classes, primary and secondary deposits, which will here be separately dealt with; both are of economic importance.

The primary ore-deposits again will be subdivided and treated according to the mineral contents which cause them again to come under distinct type-headings.

(3)—PRIMARY ORE-DEPOSITS.

A.—TIN ORES.

The primary tin ores will be dealt with under the headings of—(i) pyritic cassiterite deposits, (ii) quartz-tourmaline cassiterite veins, (iii) stanniferous contact metamorphic deposits.

(1)—*Pyritic Cassiterite Deposits.*

Although no deposits of this type have been proved to occur *in situ* on the field, mention should be made of an occurrence in the Stanley Reward alluvial. Resting on the decomposed dolomite bottom exposed in sluicing, several fairly large and a large number of small pieces of stanniferous pyrite were found, which have certainly been

derived from an ore-body of the pyritic-cassiterite type. As the pieces were all found within a comparatively small radius, it seems likely that the ore-body would be discovered *in situ* with very little prospecting. *

The ore consists of aggregates of cubical crystals of pyrite with abundant crystals of cassiterite, partly included in the pyrite, partly projecting into cavities. The cassiterite occurs in fine to medium sized crystals, varying in colour from translucent yellowish (almost colourless) through translucent brown to almost black.

The only other mineral present in specimens obtained is the non-metallic zeolite stilbite, a hydrous silicate of soda, lime, and alumina. It occurs in fine tabular crystals of reddish colour with pearly lustre in interstices between crystals of pyrite. This mineral is uncommon in lode material, but has recently been recognised in ore from the S. and M. Mine, Moina.⁽²⁹⁾ The stilbite is of no economic importance, being a secondary mineral, probably deposited from infiltrating solutions.

The ore-body from which these pieces have been derived probably exists *in situ* in the dolomite.

(2)—Quartz-Tourmaline-Cassiterite Veins.

Veins of this type are probably the most abundant in the district, judging by the alluvial tin found in various localities. Many of the "nuggets" found have undoubtedly been derived from them.

The type has already been described in detail by the Geological Survey. It is well represented in the Heemskirk district, where Mr. Waller has described the various occurrences.⁽³⁰⁾ In the North Dundas Tinfield, too, the type is not uncommon, and Mr. Ward in his description of the vein-type here,⁽³¹⁾ while remarking that the ore is of simpler composition, calls attention to the striking similarity between the two occurrences.

The occurrences in the Stanley River Tinfield are to be correlated with those of the Heemskirk and North Dundas Tinfields.

The great abundance of quartz-tourmaline veins and dykes throughout the district has already been remarked

⁽²⁹⁾ Geol. Surv. Bull. No. 14, p. 37.

⁽³⁰⁾ "Report on the Tin Ore Deposits of Mt. Heemskirk," by G. A. Waller.

⁽³¹⁾ Geol. Surv. Bull., No. 6 ("The Tinfield of North Dundas," by L. K. Ward), pp. 52-54.

upon. Geologically these are but a simpler type of the veins under discussion; the addition of cassiterite, of course, renders them of economic importance. A little work has been done on veins in various parts of the district, but in only one instance was cassiterite noticed in the deposit, although no information was obtainable concerning some of the old shafts.

Economically, then, only one representative of the type was available for inspection—that known as “Castle’s Lode.” Hence, a discussion of the type as represented in this field resolves itself into a description of one occurrence. The work done will be described later; the mineralogical constitution of the vein will here be discussed.

Mr. Ward has commented⁽³²⁾ on the impossibility of distinguishing between veins and dykes of certain types, and this occurrence illustrates the same point.

The North Dundas quartz-tourmaline-cassiterite veins are of simpler composition than those of the Heemskirk district, containing only pyrite in addition to the three minerals mentioned in the definition. Castle’s Vein (as it will be called in preference to Castle’s Lode) is of simpler composition still, so far as exposed up to the present, even pyrite being absent, quartz, cassiterite, and tourmaline (black and green) being the only minerals present. The simplicity of the type is almost certainly due to the shallow workings; if exposed at depth there is little doubt but that the vein would be found to carry pyrites, with possibly chalcopyrite and arsenopyrite. The sulphides have been leached out of the upper part of the vein by weathering agencies.

Castle’s vein is enclosed entirely within granite; the central portion consists of a somewhat irregular seam of white quartz in crystalline masses, and black tourmaline. This appears to merge on either side into a variety consisting of black and green tourmaline, quartz, and cassiterite. This merges again into the more typical “vein-rock” of Waller’s type description.⁽³³⁾ Here the granite has been tourmalinised, the place of the felspar and mica being taken by tourmaline. There are perfect pseudomorphs of tourmaline after felspar in a groundmass of quartz and tourmaline. These tourmaline pseudomorphs have already been described.⁽³⁴⁾ This zone merges gradu-

⁽³²⁾ *Op. cit.*, pp 53-54.

⁽³³⁾ *Op. cit.*, p. 8

⁽³⁴⁾ *Vide supra*, p. 32.

ally into normal granite, cut occasionally by narrow veins of quartz-tourmaline. The granite is much decomposed, even beyond the noticeable zone of tourmalinisation.

The distribution of the three constituent minerals is extremely varied. The central portion of the vein sometimes consists of masses of pure white quartz, sometimes of aggregates of coarse columnar and radiating black tourmaline with no quartz. More frequently the two are intergrown. The quartz frequently shows crystal faces. In one specimen portion of a quartz prism over 2 inches across, in section, contains inclusions of long black tourmaline needles. Sometimes the vein material consists of a fine granular aggregate of quartz and black tourmaline in approximately equal proportions and of equal grain-size. Green tourmaline and cassiterite sometimes make their appearance in the central vein; nowhere is there a sharply-defined boundary between the varieties. The bands on either side of the central vein, however, are more characteristically the habitat both of green tourmaline and tin oxide. It is striking that in no instance was cassiterite seen in the absence of green tourmaline. The latter never occurs in coarse aggregates as the black variety does; it is generally in fine radiating aggregates of needle-like individuals which have a silky lustre on fractured surfaces. Small cavities sometimes occur lined with these minute needles. In the pseudomorphs after felspar already referred to, it is invariably the minute needle-like aggregates of green tourmaline which form the replacing mineral.

Cassiterite is in granular aggregates and masses of crystals of small size, always of a brown colour, and translucent. Crystals were sometimes noticed encrusting small cavities. The cassiterite appears to be irregular in its distribution, occurring rather in scattered aggregates than in veins.

Further prospecting may considerably increase the importance of this vein type.

(3) *Stanniferous Contact Metamorphic Deposits.*

As will be seen from the following description, the Mt. Lindsay ore-body does not belong to any one well-defined type, but it has seemed advisable to describe it here under the above heading, cassiterite being the only mineral of

economic importance in an essentially contact-metamorphic deposit of magnetite with sulphides.

To present a general summary, the metallic minerals noted in approximately their relative order of abundance are magnetite, pyrrhotite, marcasite, pyrite, chalcopyrite, arsenopyrite, rutile, cassiterite.

In addition to the above, limonite, melanterite, chalcantite, pyrolusite, malachite, and native copper are present as purely secondary minerals.

The non-metallic minerals determined were quartz, hornblende, biotite, calcite, garnet, siderite, fluorite, vesuvianite, chlorite, axinite, diopside, sphene, epidote, wollastonite, sericite, tourmaline, dolomite, tremolite, orthoclase and albite.

Magnetite, or magnetic oxide of iron, Fe_3O_4 , is abundant. As well as being strongly magnetic, it is often polar. It occurs in granular masses, and disseminated through the pyritic portion of the ore-body. Although in some cases octahedral crystals were noticed in small vughs, it more usually occurs massive and granular, often with abundant biotite. Crystals of black cassiterite have frequently been observed in massive granular magnetite, frequently associated with idiomorphic prisms of glassy quartz; sometimes enclosed in quartz in magnetite, also in calcite and in garnet. The magnetite occurs often in defined bands, evidently replacing the country-rock. The zone characterised by abundance of magnetite is as much as 50 feet in width.

Pyrrhotite, magnetic sulphide of iron, slightly varying in composition, of bronze-yellow colour, is one of the commonest minerals in this ore-body. Generally occurring massive, it sometimes shows a fairly-well-defined cleavage. It is bronze-yellow on freshly-fractured faces, rapidly tarnishing. Black streak, hardness 4.5; it is usually very feebly magnetic. It occurs massive, forming bands from a fraction of an inch up to a foot or more in thickness. These bands represent original bands of country-rock which have been replaced by pyrrhotite. The examination of a number of microscopical sections has shown that this mineral is widely disseminated in the surrounding country-rock, which is situated in the contact-metamorphic zone. This examination has shown, too, the gradual progress of this replacement; it has commenced with the formation of minute threads and stringers along microscopic fracture-planes in the rock. An addition of mineral

under suitable conditions has caused these threads to widen and replace more of the country-rock. This process may have been proceeding from several adjacent parallel fissures simultaneously, the final result being as noted, whole bands of pyrrhotite of varying widths alternating with bands of country-rock only partially altered.

Excepting in the south-eastern ore-body,⁽³⁵⁾ the pyrrhotite occurs right at the surface, slightly tarnished only.

Marcasite, FeS_2 , white iron pyrites, is fairly abundant, in close association with pyrrhotite. Its very light, tin-white colour distinguishes it from the accompanying pyrite and pyrrhotite. The tin-white colour obtained on breaking fresh specimens was found to change to a more bronze-yellow after but brief exposure to the air. The structure is massive, closely resembling that of the pyrrhotite; it was not observed crystallised.

Marcasite was observed frequently along the outcrops on the western side of Tulloch Creek, practically on the surface. The oxidised crust of limonite frequently was found to be not more than 1 inch in thickness, below which was fresh pyrrhotite and marcasite. It is rather surprising to find unaltered marcasite under these conditions.

The marcasite would seem to be not a primary mineral, but secondary, and the occurrence very strongly suggests that it represents an intermediate product in the conversion of pyrrhotite to limonite. This confirms an observation previously made by Mr. L. K. Ward on the North Dundas Tinfield.⁽³⁶⁾ In the Renison Bell-Montana-Boulder lode-system marcasite is always present on the surface of the oxidised "floors" of ore; however, in this case pyrrhotite is absent in the crust containing marcasite.

Chalcopyrite, CuFeS_2 , copper pyrites, is not an important constituent, but is constantly present in the sulphide ore in small amounts sporadically distributed through the other sulphides. It occurs massive, and the microscope reveals the fact that it usually coats and fringes the pyrrhotite, showing that it is later than pyrrhotite.

The question was asked on the field, "Is the copper pyrites likely to increase in depth?" There is no reason to believe that such will be the case. The small amount present certainly seems to be primary.

Chalcopyrite is usually present in pyritic tin-deposits.

⁽³⁵⁾ *Vide infra*, pp 148-152.

⁽³⁶⁾ *Op. cit.* p. 68.

Pyrite, FeS_2 , iron pyrites, or mundic, is quite subordinate in amount, but is certainly present in the formation. It occurs in crystalline masses closely associated with the pyrrhotite in certain zones, and was frequently noticed in the altered slate towards the edges of the deposit, in small cubical crystals.

Arsenopyrite, FeAsS , mispickel, is present in small amount in scattered silver-white crystals. It is very fresh, and generally appears in the only partially replaced slate bands in the formation, rather than in the other sulphides.

Rutile, TiO_2 , is not noticeable in hand specimens, though the microscope reveals its presence in the ore-body; it is particularly noticeable in the axinitic material occurring in the No. 1 trench, east of Tulloch Creek, where it occurs in minute prisms, highly idiomorphic, which in some instances show typical geniculated twinning on the 101 twin plane. The mineral is not of any economic importance.

Cassiterite, SnO_2 , tin oxide, is the only ore of tin present. Search was made for stannite in various parts of the ore-body, but without success; if present at all, it is in extremely small quantities. The cassiterite occurs in crystals up to 3.5 mm.; it is generally opaque, and black or brown in colour, but sometimes becomes translucent. The presence of crystals of cassiterite in dense magnetite has already been remarked on. The distribution of the cassiterite appears to be irregular, and as yet little definite data is available to explain its occurrence. In various parts of the large formation rich veins undoubtedly do occur. In the south-eastern ore-body there are some rich seams of high-grade tin oxide, but in addition, in certain zones it seems to be distributed through the sulphides, or through the gossan resulting from their oxidation, in sufficient quantities to render the ore of payable grade. Instances were noted on the exposed outcrop of the ore-body on the east side of Tulloch Creek, of abundant crystals of cassiterite of about 3 by 3 mm. lining a fissure which cut across at a sharp angle, the bands of pyritic ore and partially-replaced country-rock, showing clearly that portion, at any rate, of the tin had been introduced subsequently to the formation of the main sulphide body.

Quartz, SiO_2 , is fairly abundant throughout the ore-body. It frequently occurs in idiomorphic prisms, varying greatly in size, from minute acicular needles to prisms $1\frac{1}{2}$ inch long by $\frac{1}{2}$ -inch section. These were observed in the

massive pyritic ore at times, also in massive granular magnetite, where it is frequently associated with cassiterite. In the pyritic ore the quartz is brought into relief by weathering: in several instances pyrites had decomposed and been removed by weathering agencies, leaving the prismatic quartz apparently occupying open spaces. Here the crystals were in several cases seen to be thickly encrusted with brown cassiterite.

Microscopical examination of thin sections of ore material shows that there are several generations of quartz. Original minute crystals have been gradually enlarged by the addition of silica, and although now in optical continuity, the different layers are rendered apparent by minute inclusions of foreign material. It was noticed, too, that in more than one instance small idiomorphic quartz crystals, showing very sharp crystal outlines, were wholly included in allotriomorphic quartz, which has evidently filled interstitial spaces between some of the earlier crystallised minerals.

Neither chalcedony nor opal was noticed.

Hornblende, or amphibole, silicate of iron, magnesium, aluminium, &c., is surprisingly abundant as a gangue mineral in the sulphidic ore-body of the Mt. Lindsay Mine. Unfortunately, no analysis of the mineral is available, so that its composition is at present unknown. It occurs as black prismatic and radiating monoclinic crystals. With pyrrhotite as its accompanying metallic mineral it forms large masses. The crystals are subidiomorphic, prisms varying in size to 4 mm. by 10 mm. This pyrrhotite-hornblende is extremely hard and tough. Such slow progress was made in driving the Tulloch adit (on the western side of Tulloch Creek) in this material, that the work was suspended. The same difficulty was encountered, too, in driving a short adit in continuation of Cameron's cut (No. 1 trench).

Microscopically the hornblende is usually bright green in thin section, although in one slide it is so choked with iron oxide as to be quite opaque. Usually it is quite transparent, highly pleochroic, and shows quite normal cleavages, extinction angles, and other optical properties. It is generally associated with a little brown biotite, which sometimes quite includes it, and so has evidently crystallised later than the hornblende. When associated with pyrrhotite, the latter is younger, filling interstices

between the idiomorphic or hypidiomorphic hornblende, and being entirely moulded on it.

Biotite, or black mica, approximately $(\text{HK})_2 \cdot (\text{MgFe})_2 \cdot \text{Al}_2(\text{SiO}_4)_3$, is another very common gangue mineral. It is black in colour, and usually in small scales and plates, rarely more than 2 mm. across. It occurs closely associated with hornblende, and is younger than the latter. Biotite is very abundant in the surrounding country-rock, being developed as a secondary mineral arising from the contact metamorphism of argillaceous sedimentaries by the granite intrusion. In some portions of the ore-body it forms the most abundant gangue mineral, occurring in idiomorphic brown crystals with frayed-out ends. Near Tulloch Creek it occurs with quartz, fluorite, and magnetite, and in several portions of the ore-body forms, with magnetite, well-marked and extensive zones.

Calcite, CaCO_3 , is present in subordinate amounts throughout the ore-body. A good deal of it is certainly secondary, and has been deposited in recent fissures from solutions which have filtered in. Some, however, appears to be a true replacement mineral.

It occurs in No. 3 trench in dense granular magnetite, with a little glassy prismatic quartz. Here it is closely associated with cassiterite, which occurs both in the magnetite and also in the calcite, in black crystals up to about 3 by 3 mm. In the No. 2 south crosscut from the south-east adit, at about 1 foot from the face, and constituting the face of the drive at the time of my visit, was a very hard rock composed essentially of calcite and garnet. Throughout the ore-body thin sections cut from samples from various points disclosed the presence of calcite, where it is not noticeable macroscopically.

Garnet, a silicate of Fe, Ca, Mg, &c., is fairly abundant.

The other gangue minerals are subordinate in amount and distribution, and as they are referred to in the course of this description, they scarcely merit detailed notice here.

A close study of the ore-deposit *in situ*, of hand-specimens collected therefrom, and of thin slides cut from various portions, has led the writer to draw some definite conclusions with regard to the relationship of the constituent minerals to each other and to the enclosing rock, and from these conclusions the genesis of the deposit can be reasonably explained.

A glance at the list of minerals present shows at once that we have not a simple vein-type to deal with. The abundant magnetite and pyrrhotite with the group of lime-silicates, suggests a contact deposit of the "Kristiania" type, while cassiterite and other metallics with boron and fluorine bearing minerals strongly suggest a pneumatolytic tin ore deposit.

As a result of his examination the writer is of opinion that we have two phases of ore-deposition, with a definite time interval between them. In the earlier stage magnetite and pyrrhotite were deposited, with amphibole, garnet, idocrase, wollastonite, diopside, calcite, and epidote as gangue minerals. Probably no cassiterite was formed at this time, and had no further action taken place the ore-body would probably have had little economic value.

At a somewhat later period, cassiterite, chalcopyrite, pyrite, arsenopyrite, and rutile were introduced, with accompanying quartz, garnet, biotite, fluorite, tourmaline, axinite, calcite, siderite, and dolomite.

Reasons for this opinion, and further details of the mineral associations, will now be given.

As descriptive of the distribution of the various minerals in the ore-body, it may be well to consider a detailed section across the formation.

Of the different exposed sections, that in No. 2 trench,⁽³⁷⁾ cut under the direction of Mr. A. E. O'Brien, is one of the most complete available, and will be here considered in detail.

The following description refers to the variation observable in the ore-body as exposed in No. 2 trench, proceeding from the hanging-wall to footwall side, *i.e.*, from south-west to north-east. The trench is over 100 feet in length, and varies from $1\frac{1}{2}$ to 3 feet in depth. It will be seen that there is not 100 feet of ore, this width including many unreplaced bands of country-rock, all more or less altered and mineralised. Unfortunately, assay values are not available to show which are really the stanniferous zones.

Fifteen feet.—For the first 15 feet a detailed examination could not be made, as it was filled with water.

Speaking generally, however, we have alternate bands of mineralised slate and dense magnetite with biotite.

(37) *Vide* Plate VI.

One foot.—Very hard, tough, altered slate, carrying garnet and impregnated with fine pyrites.

One-inch seam carrying transparent crystallised calcite, nests of tetragonal prisms of greenish-brown translucent vesuvianite, with some pink garnet. There is a little disseminated pyrrhotite (magnetic) and sporadic chalcopyrite. Both vesuvianite and pyrrhotite are included in the calcite.

Six inches of hard altered slate, mineralised.

Nine inches of finely granular magnetite, with a little black biotite, carrying a good deal of dull decomposing pyrite or pyrrhotite, and a few splashes of chalcopyrite.

Three inches of hardened slate.

One foot 3 inches of dense magnetite, finely granular, with pyrrhotite in subordinate amount, and a little chalcopyrite.

Six inches of altered slate, very hard, showing disseminated pyrites.

Four inches of magnetite—pyrrhotite lode matter with a little chalcopyrite. A few scattered crystals of black cassiterite were noticed here.

Six inches of altered slate.

One inch of fresh pyrrhotite and marcasite, with chalcopyrite. There is a good deal of calcite present; the groundmass is magnetite and biotite.

One-foot band of dark-coloured slate not entirely replaced. The groundmass is largely of biotite and magnetite with some siderite in fine crystals showing cleavage faces, cut through by seams of pyrrhotite and marcasite carrying a little chalcopyrite.

Ten feet almost completely replaced, only a few narrow bands of slate remaining. Throughout, well-defined banded structure is noticeable. The minerals present are essentially magnetite and pyrrhotite, with local variations. In some bands biotite forms a considerable proportion of the groundmass. The pyrrhotite occurs both in well-defined bands and in scattered blebs. Associated with it is chalcopyrite sparingly distributed. A little arsenopyrite was noticed in scattered crystals. Siderite appears in the groundmass in some bands, and calcite is present filling small fissures cutting through the banded aggregates of other minerals.

Ten feet of outcrop now occur, the detailed examination of which was hampered, as this section forms the bed of Tulloch Creek. It is similar to the previous 10 feet, well banded, with occasional narrow bands (up to 1 inch) of slate not completely replaced by metallic minerals, but containing abundant biotite.

In this dense magnetite zone is an interesting occurrence of cassiterite, and one which throws some light on the mode of origin of that mineral. In irregular nests and pockets through the dense granular magnetite are associated the following minerals:—Quartz, calcite, fluorite, chalcopyrite, cassiterite. In one place some pink garnet was noticed with calcite. The quartz is crystalline, prisms up to $\frac{1}{2}$ -inch by $1\frac{1}{4}$ inch long being noticed. The calcite shows typical rhombohedral cleavages, while the fluorite is in crystalline masses of an amethyst tint. Chalcopyrite is in amorphous masses. The cassiterite is translucent brown to black in colour, and is well crystallised; the crystals are frequently twinned; in size they vary from minute crystals to prisms $\frac{3}{16}$ -inch by $\frac{1}{2}$ -inch long. The occurrence of the tin oxide is interesting: crystals were noted included in quartz, included in calcite, also in fluorite, and around the edges of these pockets, included in dense granular magnetite. In one specimen fairly coarse cassiterite crystals occur in a cavity lined with minute octahedral magnetite.

In one band of slate about 4 inches in width is a vein, about 1 inch in width, of dark coloured non-metallic minerals with a little distinguishable white calcite, showing a narrow selvage of pink garnet on the edge. The microscopical examination of a thin section cut from this seam shows that it consists essentially of vesuvianite and garnet, with accessory calcite, epidote, chlorite, and magnetite. The vesuvianite is in masses of prisms showing hypidiomorphic outlines. The prismatic crystals sometimes form a structure resembling the "comb structure" seen in quartz which has crystallised in fissures. The terminal crystal edges are well defined, while the interstitial space between two approaching sets of prisms is filled with calcite. Although

the prismatic form of the crystals is clearly discernible, aggregates of prisms are in optical continuity, extinguishing simultaneously between crossed nicols. The form of the prisms is sometimes brought into relief by narrow threads of calcite included between adjoining crystals. In some cases fine veinlets cutting through the prism aggregates are filled with calcite. The garnet is in masses and granular aggregates; it appears to occupy one definite area, and the vesuvianite another, though to a small extent granular masses of garnet occur nearly surrounded by vesuvianite. The junction between the two is generally marked by calcite.

A few grains of epidote are present, a little fine disseminated magnetite, and a few scattered aggregates of chlorite.

Continuing the section across Tulloch Creek we have—

Four feet of banded marcasite and pyrrhotite, with narrow residual bands of altered slate. There are bands of marcasite from 1 to 6 inches in width, in a crystalline groundmass, containing chlorite and hornblende. Hornblende is abundant in this zone, almost completely occupying certain bands, with irregular scattered masses of pyrite and pyrrhotite, with some chalcopyrite. Abundant fine biotite is seen in the groundmass, and a little siderite.

In one seam of coarse marcasite quartz occurs in idiomorphic prisms, with chalcopyrite filling interstitial spaces.

Four feet of decomposing pyritic material, banded, with occasional narrow bands of country-rock. In the pyritic material chalcopyrite and magnetite were noticed, with some hornblende as a gangue mineral.

One foot 6 inches of decomposed pyritic material in a soft, thoroughly chloritised groundmass.

Two feet of marcasite, with a little chalcopyrite and brown cassiterite in a groundmass of siderite and quartz with fluorite, merging gradually into garnetiferous slate, with pyrite and pyrrhotite. Microscopically, siderite is seen to occupy a considerable portion of the groundmass. Magnetite is present in scattered grains and aggregates, forming threads in the less altered bands of country-rock. Pyrrhotite is evidently a replacement mineral and

is associated with a little idiomorphic tourmaline and fluorite. The occurrence of fluorite is striking. It occurs in fissures in the previously-formed lode material. These fissures do not conform with the general strike of the bands. Microscopically it is seen to have cubical outlines, and to be replacing the groundmass. Cassiterite occurs in close association with fluorite, as does quartz. In addition to the minerals already mentioned, sphene is recognisable microscopically in scattered idiomorphic grains and granular aggregates.

A variation of the lode material here merits special mention and description, as it is of peculiar interest, and helps to throw light on the mode of origin of the deposit.

Hand specimens remind one, in general appearance, of a gabbro. The rock is of a dominant dark-green colour, with abundant plates of some dark ferromagnesian mineral. The white mineral in the groundmass is seen, on a closer examination, to be calcite. Aggregates of brown cassiterite are sometimes seen; also some scattered pyrrhotite. A good deal of the groundmass is indistinguishable.

Microscopically, the following minerals are seen to be present:—Calcite, axinite, hornblende (?), chlorite, fluorite, vesuvianite, epidote, sericite, pyrrhotite, cassiterite, rutile, limonite.

The groundmass of the slide consists largely of calcite, a good deal of which is evidently secondary. Axinite occurs in plates showing sharply idiomorphic outlines, of typical wedge-shape. These plates sometimes show undulose extinction between crossed nicols. They are large, and carry abundant inclusions of chloritic aggregates and of rutile, and also some cassiterite. In most individuals more or less calcite has separated out, frequently in the centre of the crystals. The shape of some of the calcite plates suggests that they are pseudomorphs after axinite. The ferromagnesian mineral is now too cloudy and decomposed to be exactly determined in this slide. The outlines and few remaining fragments suggest hornblende. There is a little fluorite present. Vesuvianite is present as included grains in the later-formed minerals. Rutile is well disseminated through the slide,

occurring in sharply idiomorphic minute prismatic crystals, showing typical geniculated twinning in some individuals. It occurs as inclusions in most of the other constituents, and seems closely associated with the cassiterite, which is present as idiomorphic crystals and granular aggregates, frequently included in the axinite. The other minerals mentioned occur in small quantities only.

A peculiar structure noticed in this part of the ore-body was a radial intergrowth of pyrrhotite with some mineral now entirely decomposed and represented by kaolin. These radial aggregates are up to $1\frac{1}{2}$ inch diameter.

Continuing the section across the ore-body we have—

Three feet 3 inches of mineralised slate. The slate is much hardened, and carries disseminated fine pyrites throughout, but retains remarkably well the original banding, indicating slight differences in composition. It breaks with a conchoidal fracture. There are several minute faults cutting across the bands in various directions, and displacing the slate bands varying distances up to about 1 inch. These fault-planes are all filled with pyrites.

Six inches of soft decomposed pyritic material in a groundmass with biotite and magnetite.

Five inches of dense magnetite, finely granular, and very hard and dense. A little fluorite was noticed, and some siderite, and some aggregates of cassiterite crystals.

Four feet 6 inches of soft decomposing iron sulphides, with traces of chalcopyrite. Gangue minerals are decomposed, but a little biotite was recognisable. Magnetite is present in amount subordinate to the pyritic material.

Three inches of finely granular magnetite, with apparently no other mineral.

One foot decomposing marcasite and pyrrhotite with chalcopyrite.

Eleven feet of alternating bands of country-rock and mineral, including 8 feet 9 inches of country-rock and 2 feet 3 inches of mineral. The mineral is mostly pyrrhotite, frequently decomposing, magnetite being present in some bands.

Following this we have a narrow but well-defined parting-plane introducing a distinct mineralised zone 1 foot 6 inches in width, characterised by excess of quartz.

There is a white quartzose groundmass carrying abundant clear, glassy prismatic crystals of quartz and pyrite rather irregularly distributed. The quartz prisms occur up to $\frac{3}{16}$ -inch in section. These occur also in geodes as perfect crystals, with a little pyrite and abundant small idiomorphic crystals of black and brown cassiterite, partly encrusting the quartz prisms, partly forming crusts on the walls of the cavities. The cassiterite seems in all cases to be associated with crystalline quartz.

Six inches of decomposing slate with impregnations of fine pyrite.

Three-inch seam of finely crystalline pyrite and siderite, showing abundant crystals of brown cassiterite.

Nine inches of alternating narrow bands of slate and of pyrite and pyrrhotite.

One inch of pyrrhotite with siderite and fluorite. The three minerals seem quite distinct in this instance, sometimes one predominating and occupying the full width of the fissure, sometimes the other. The impression given is that the pyrrhotite has been the first formed mineral, followed by siderite, and finally fluorite.

Six inches of bands of pyrrhotite in slate. The pyrrhotite is associated with siderite, and sometimes with fluorite, prismatic quartz, and a little brown cassiterite.

A microscopic slide cut from one portion of this lode material shows the presence of siderite, quartz, pyrrhotite, magnetite, chlorite, and rutile. Plates of siderite occupy a large part of the slide, but quartz is fairly abundant in highly idiomorphic crystals. These sometimes show secondary growth by the addition of silica subsequent to the formation of the original minute idiomorphic prisms, the different layers being marked by numerous microscopic inclusions, the whole crystal being optically continuous. The quartz is frequently surrounded by magnetite. The rutile is in scattered idiomorphic crystals, sometimes included partly in siderite and partly in quartz, also entirely enclosed in quartz. Chlorite is present in tufted aggregates.

Four feet of sulphides with very little gangue. Marcasite and pyrrhotite form the bulk of this band, with a little scattered chalcopyrite. There is very little gangue present, and no country-rock, but by almost imperceptible changes in texture the whole retains remarkably well the banded structure of the country-rock it replaces.

Nine inches of narrow bands of pyrrhotite, sometimes with fluorite and traces of chalcopyrite in slate. Mineral bands vary from less than $\frac{1}{8}$ -inch to over 1 inch in thickness.

Six feet of altered country-rock carrying veins of pyrrhotite of varying and irregular width. Some veins contain practically no gangue; in others siderite is present, and sometimes nests of idiomorphic prisms of quartz. In one instance prisms of quartz are embedded in a groundmass of grey calcite, and are associated with abundant brown cassiterite crystals. Bands up to 2 inches of impure calcite occur, with very irregular masses of pyrrhotite, sometimes in mere threads cutting across the cleavage directions of the enclosing slate, at other times running parallel with these cleavages, and again widening to the full width of the seam.

Where there is any slate remaining, the bands are much hardened and altered. They are cut through in all directions by a network of microscopic fissures, often hair-like in breadth, carrying fine pyrites or pyrrhotite. In other parts fissures seem to be wanting, and the slate is impregnated with fine pyrites. In these altered slate bands the microscope reveals the presence of calcite, biotite, albite, quartz, magnetite, and pyrrhotite.

Three inches of pyrites in siderite and a soft chloritic groundmass, carrying good brown tin oxide.

One foot 3 inches of hard altered slate, carrying very fresh crystals of arsenopyrite sporadically distributed.

This slate becomes much more altered by the development of pink garnet on approaching

Two-inch seam of hornblende—pyrrhotite lode-matter, with distinguishable calcite, quartz, vesuvianite, and chlorite.

In addition to the minerals named, the microscope reveals the presence of fairly abundant aggre-

gates of brown biotite, and of scattered grains of epidote. The green hornblende is highly pleochroic, but does not show definite crystal outlines. There are veinlets cutting through the other constituents filled with calcite.

This vein is cut at an angle by a $1\frac{1}{2}$ -inch seam of coarse pyrrhotite and white siderite. The siderite appears to intersect the previously-formed pyrrhotite at various angles. With the pyrrhotite are splashes of chalcopyrite.

One foot of hard country-rock, with disseminated pyrite.

One foot of decomposing pyritic material. Some crystals of fresh arsenopyrite were noticed in a narrow residual band of slate.

Nine inches of country-rock, with some pink garnet.

Two feet of definitely banded finely granular pyrrhotite, with some marcasite. Chalcopyrite is fairly abundant, and in some bands cassiterite is present in fine brown translucent crystals. Fresh arsenopyrite was also noticed. The groundmass contains abundant siderite and chlorite.

One foot of similar material, but carrying rather denser sulphides, and without noticeable cassiterite.

Here, again, a well-defined seam about 1 inch in thickness cuts across the regular cleavage-planes of the slates and the bands of mineral. It consists of marcasite, chalcopyrite, and arsenopyrite in a gangue of quartz and fluorite.

Three inches of country-rock, with abundant scattered sulphides.

Two feet of decomposing iron sulphides.

Two feet of decomposed gossanous material, very soft, consisting essentially of abundant coarsely crystalline prisms of quartz. There are signs of pyritic material remaining.

Six inches of weathered brown slate.

One inch of very decomposed pyritic material.

One foot 6 inches of weathered ironstained slates.

Three feet of very hard compact slate, with abundant finely disseminated pyrites.

The general characters of the sulphide ore-body are similar to those just described. There are, of course, local variations from point to point, some of these being of interest and importance, but in general the structure and

mineralogical association differ little from the type section taken. It seems advisable to refer to the various exposures of the ore-body made in the course of exploratory work, and without describing each in full detail, to refer to special occurrences.

In the No. 1 trench there is exposed a zone of 44 feet of lode material characterised by the presence of magnetite on the hanging-wall (south-western) side. The banded structure is similar to that already described as occurring in No. 2 trench, alternate bands of slate and of metallic and gangue minerals occurring. The magnetite is sometimes very dense and finely granular, with apparently little or no other associated mineral, but it commonly occurs with one or more of the following minerals:—Siderite, biotite, hornblende, garnet, pyrrhotite. A little prismatic quartz and nests of tin oxide crystals are sometimes seen. One band of about 4 feet carries abundant green chlorite with magnetite and siderite, and quartz is present in highly idiomorphic crystals. Crystals of brown cassiterite are disseminated through this band. One occurrence noted in this band is of peculiar interest. A specimen collected by Mr. A. E. O'Brien showed a mass of red garnet, shaped approximately as an equilateral triangle in section, the length of side being $3\frac{1}{2}$ inches. On one edge is a mass of crystallised pyrite with a little calcite; with this exception there appears to be no other mineral included in the garnet. But forming a border all round the garnet are numerous crystals of black cassiterite, with a little calcite and a few prisms of glassy quartz. The groundmass appears to consist of a little quartz and siderite in a dark-greenish base. Microscopically examined, the ore is seen to be composed of quartz, siderite, biotite, cassiterite, magnetite, chlorite, tourmaline, and opaque chloritic masses containing magnetite and limonite of quite irregular shape, determined by the other constituents. Much of the quartz is highly idiomorphic, while other again is quite allotriomorphic. It is frequently included in siderite. The biotite is in aggregates of minute flakes, and would seem to be later than both quartz and siderite, partly replacing both. Cassiterite is abundant in the slide in grains and crystals partly replacing both quartz and siderite. Associated with it is a little green tourmaline. This appears to merge into about 1 foot of magnetite with a little siderite, containing abundant radial aggregates of hornblende, which in section are circular and of about $\frac{1}{8}$ -inch diameter.

Within a few feet of this occurrence is a 5-inch seam which seems to merit special mention on account of the structure and mineral association. The central 3 inches is well banded, consisting sometimes entirely (apparently) of crystalline magnetite, more usually magnetite, siderite, and chlorite, intersected occasionally by narrow fissures filled with quartz. This central band is flanked on either side by a seam of about 1 inch, composed typically of idiomorphic quartz in prisms up to $\frac{1}{2}$ -inch section. With the quartz sometimes occurs crystalline magnetite, also pyrite. In one portion red garnet was abundant with the quartz. The quartz prisms at times penetrate the central zone, or may even occupy the full width (5 inches) of the seam. The walls are sharply defined, and are coated with magnetite crystals. The seam is approximately vertical, the strike corresponding with that of the country-rock and main ore-body.

Another feature in this magnetite zone worthy of notice is the occurrence in dense magnetite of vughs completely lined with minute crystals of black magnetite and brown translucent cassiterite. The association of the two is interesting, and a close examination discloses the significant fact that the short tetragonal prisms of cassiterite rest on, and sometimes encrust, the magnetite. It is significant, too, that prismatic crystals of quartz are noticeable in some of these cavities.

One type of lode material which has not yet been described in detail, but which is very abundant, is the hornblende-pyrrhotite variety. At the north-eastern (*i.e.*, footwall) end of this No. 1 trench an adit has been commenced and driven for about 6 feet entirely in this material, which is here very massive. It is extremely hard and tough. Typical specimens examined macroscopically show abundant pyrrhotite scattered through a crystalline groundmass of greenish-black hornblende. The pyrrhotite forms irregular veins in places. It is associated with a little chalcopyrite; sometimes magnetite and biotite are noticeable in the groundmass. The microscopical examination of a thin section shows that hornblende and pyrrhotite are the most abundant constituents, with a smaller amount of biotite and a little magnetite, chalcopyrite, tremolite, and quartz. The hornblende is in idiomorphic crystals which are highly pleochroic and of a bright-green colour. The biotite is in clusters of brown idiomorphic crystals, with frayed-out ends.

Pyrrhotite is a later product of crystallisation than the hornblende, being moulded on, and sometimes almost entirely surrounding idiomorphic crystals of the latter mineral. Magnetite certainly seems to be the earliest mineral formed. It occurs in scattered grains sometimes included in masses of pyrrhotite and included also in hornblende. Chalcopyrite is present in small amount only. It is later than the pyrrhotite, occurring as a fringe to masses of that mineral, but never included in it. A little colourless tremolite is closely associated with the green hornblende, apparently forming an extension of the crystals, though not in optical continuity with them. Quartz is present only in very small amount, quite allotriomorphic, filling interstitial spaces between the idiomorphic hornblende crystals. The biotite must be later than the hornblende, as there is clear evidence that it has almost completely replaced crystals of the latter mineral.

No. 1 trench has not been continued across to the foot-wall side of the ore-body, but the outcrop is exposed. Here the character of the ore is decidedly more quartzose; veins of cassiterite up to 1 inch in width were noticed at various points, sometimes with decomposing iron sulphides, frequently associated with crystallised prismatic quartz. Although sometimes conforming with the general strike, it is worthy of particular notice that in several instances fissures filled with brown translucent crystals of cassiterite were noticed cutting across the bands of slate, magnetite, and sulphides. Obviously, these could only have been formed and filled with tin oxide *after* the consolidation of the magnetite and sulphides.

The occurrence of cassiterite with crystallised quartz, though not universal throughout the ore-body, is general. It is striking in what is known as the south-eastern body. In the winze is a typical example of this occurrence. A seam up to 3 inches in width consists essentially of quartz, cassiterite, and decomposing pyrite. The walls of the fissure are encrusted with cassiterite, the central portion of the seam being filled with prisms of quartz, from minute needle-like prisms up to about 3 millimetres in section, showing terminal pyramidal faces. These prisms are lying at all angles, and sometimes show terminal faces at either end. They sometimes include, and frequently are quite encrusted by, crystals of cassiterite; on the same mineral the bases of some of the prisms rest. At places the fissure is filled with quartz and pyrite, and no cassiterite is noticeable.

A variation from this type is the vein of tin oxide first cut in the No. 3 north crosscut from the south-east adit, and afterwards opened up by an intermediate drive, connecting with the rise from the No. 3 crosscut to the surface. The main seam is as much as 4 inches in places of massive cassiterite, while at times there is about 2 feet 6 inches of gossan, with a series of parallel fissures up to about 1 inch filled with cassiterite. The tin oxide is brownish-black in colour, and massive to granular in texture. It is banded, the strike conforming exactly to that of the enclosing country-rocks. Sometimes minute fissures cut across the regular banding filled with crystals of cassiterite. Small cavities in some places filled with limonite suggest the oxidation of a small amount of pyrite present in the primary ore. No quartz was noticed in specimens from this locality.

Further details of the ore-body will be given under the heading of the mining properties. While the preceding description of the mineral associations and the variations in the nature of the ore-body at Mt. Lindsay is not by any means complete, it was considered advisable to include some descriptive matter here in order to render intelligible the following brief discussion of the genesis of the deposit.

The problem presented for solution is not a simple one. The phenomena of contact-metamorphism must be taken into consideration in conjunction with the ore-forming processes. There seems, however, sufficient evidence to justify at least some general conclusions being drawn. Unfortunately no analyses are available; this detracts from the value of the conclusions drawn, and in some cases renders definite decisions impossible.

With regard to the ore-body as a whole, how is the remarkable banded structure to be explained? As we have already seen, the bands of ore material correspond almost exactly in strike and dip with the surrounding sedimentary rocks, and in fact bands of ore are separated from each other by bands of slate. Can they be bedded deposits⁽³⁸⁾? Can the banded structure be due to crushing by dynamic metamorphism?

Obviously, with the evidence available, neither of these suppositions is tenable. The mineral associations, the internal structure of the ore material, the intense metamorphism of the included sedimentary bands, and the mineralisation of the adjoining rocks by the same agencies

⁽³⁸⁾ This question was asked the writer on the field, hence its inclusion in this discussion.

which produced the ore-body itself, all emphatically disprove this theory. The same arguments may be applied to the second theory. In addition, there is no evidence whatever to show that crushing has taken place since consolidation, and the ore-body has still to be accounted for.

The only explanation which is in accordance with observed facts is that *the material now constituting the bands of metallic and gangue minerals must have been introduced, and that these bands have actually replaced portions of the original country-rock. The ore-body is actually a metasomatic replacement deposit.*

It may be advisable to briefly summarise the outstanding features of the deposit before discussing the genesis.

It is situated in a series of Pre-Silurian stratified rocks, mainly slates at this point, which have been converted by an intrusive granite mass of Devonian age into hornstones. The ore-body is proved to extend to within 5 chains of the exposed granite contact, and is entirely within the contact metamorphic zone.

The ore-body consists of bands of metallic and gangue minerals varying in width from a fraction of an inch to several feet, alternating with residual bands of country-rock. The mineralised zone is about 100 feet in width, and corresponds in strike and dip with the enclosing sedimentary rocks.

The country-rock (hornstone) contains actinolite, biotite, andalusite, quartz, sillimanite, chlorite, and disseminated pyrite and magnetite.

Magnetite is abundant in the ore-body, associated with lime-silicates, but sulphides are also present in considerable quantities.

Cassiterite, quartz, fluorite, tourmaline, and axinite are also present, and it is the presence of cassiterite which gives the deposit its economic value.

The writer is of opinion that the ore-deposit under consideration is to be classed with the contact-metamorphic epigenetic ore-deposits of Beck,⁽³⁹⁾ into which the cassiterite and accompanying minerals have been introduced by pneumatolysis.

The ore-body is a true replacement deposit. In a recently published paper on "Replacement Ore-bodies,"⁽⁴⁰⁾ J. D. Irving has classified and discussed the

⁽³⁹⁾ "The Nature of Ore Deposits," by Dr. R. Beck, trans. W. H. Weed, First Edition, p. 582.

⁽⁴⁰⁾ Replacement ore-bodies, by J. D. Irving, in "Types of Ore-deposits," edited by H. Foster Bain (1911), p. 252.

criteria by which replacement bodies may be recognised. Even bearing in mind the warnings given by Professor Irving, the facts noted seem capable of only one interpretation. He states ⁽⁴¹⁾: "The criteria for the recognition of replacement which has been discussed . . . apply only in minor degree to contact-metamorphic types." And again ⁽⁴²⁾: "It is important to understand that the criteria which are most serviceable in recognising replacement may most of them be eliminated by regional metamorphism."

In the present instance no regional metamorphism has taken place since the close of the period of ore-deposition. Hence any criteria afforded by the ore-body should be available for examination and interpretation.

The criteria established by the writer quoted, which are applicable to the Mt. Lindsay ore-body, will now be discussed.

1. *The Presence of Complete Crystals in Foreign Rock-masses.*—In many instances the slates, although hardened, retain remarkably well their fine banded structure when viewed microscopically. Several examples were noticed of cubical crystals of pyrite in such slates, the banded structure not being disturbed in any way, but the crystal faces intersecting them at an angle.

2. *Preservation of Rock Structures.*—This criterion is abundantly exemplified in the ore-body. It is shown both in places where non-metallics predominate, in dense sulphide bands where little gangue is present, and in magnetite. This feature is striking in all parts of the ore-body. In the case of non-metallics slight differences in texture and in the actual composition of the minerals in adjoining bands show in detail the original rock-structures. Even in the sulphidic portions this structure is distinct, though it is sometimes very difficult to determine exactly what brings the banding into relief. Sometimes there is a marked difference in texture, or again the gangue minerals in adjoining bands are different (frequently only very slightly) in amount, in composition, or in texture.

3. *Absence of Crustification.*—In discussing this feature cassiterite and accompanying pneumatolytic minerals already referred to are not included; they do in some instances show crustification, but this will be explained by

⁽⁴¹⁾ *Op. cit.*, p. 293.

⁽⁴²⁾ *Op. cit.*, p. 252.

their slightly different mode of origin from that of the main ore-body.

A careful examination failed to reveal evidences of crustification. In the case of some of the mineralised bands a structure somewhat resembling this was observed, but it is due not to the filling of an open fissure, but to the gradual replacement of a band of country-rock which lies between two fissures. Replacement has proceeded from each fissure, and eventually the strip of rock has been completely replaced, the two mineralised bands coalescing. The presence of narrow residual bands of incompletely replaced rock in such cases gives the clue to the mode of origin.

Referring to this criterion, Professor Irving⁽⁴³⁾ remarks: "Crustification, if present, is a definite evidence of the formation of ores in an open cavity, but its absence by no means indicates that a deposit has been formed by replacement."

Hence this feature of itself is not decisive, but is of considerable value when taken in conjunction with other criteria definitely recognised.

4. *Presence of Unsupported Structures.*—The general structure of the ore-body has already been described, and the presence of bands of country-rock of various widths running continuously for sometimes great distances through the ore-body, parallel to each other, and to the bands of mineral. Had the intervening bands of country-rock (now represented by ore and gangue minerals) been dissolved out, and the minerals referred to subsequently introduced, the residual strips of country-rock could not have remained in their present undisturbed condition; hence replacement processes are assumed to be responsible for the substitution of the various metallic and non-metallic minerals for country-rock.

5. *Presence of Cavities Left by Decrease in Volume, due to Changes in Composition.*—Irving⁽⁴⁴⁾ states: "It rarely if ever happens that material substituted for country-rock is of equal volume with the original material. The varying densities of minerals and proportions of the new and old minerals taking part in the reactions usually result in a very marked change in volume."

Unfortunately, some of the data requisite for a full discussion of this question are wanting, but the writer wishes

⁽⁴³⁾ *Op. cit.*, p. 233.

⁽⁴⁴⁾ *Op. cit.*, p. 292.

to call attention to certain occurrences which, in his opinion, are accounted for in this way. At intervals throughout the ore-body cavities do occur in dense mineral, which do not seem to have been caused by solution or to be residual open-cavity spaces unfilled by introduced mineral. For instance, in dense magnetite these were noticed in various places, comparatively small in size, and of very irregular and intricate shapes. In some cases these are lined with octahedral crystals of magnetite; in one case cassiterite crystals had been deposited on previously formed magnetite crystals.

In view of the above considerations, the writer is strongly of opinion that the *main ore-body is a true replacement deposit.*

The ore-body consists of a number of what Irving⁽⁴⁵⁾ has called "lode fissures." The ore-bearing solutions have ascended by a number of minute parallel fissures, caused by the intrusion of the granite-mass, and have gradually replaced the country-rock on either wall of the fissures; sometimes the fissures have been closely spaced, and the replacement of the intervening band of country-rock has been complete; at other times the fissures have been more widely spaced, and the replacement has not been complete. The spacing of the fissures has not been the only factor which has determined the non-replacement of certain bands of country-rock. The chemical composition of the original layers has been an extremely important factor. Speaking generally, the more calcareous and aluminous strata have been replaced in preference to the more siliceous.

In the above discussion of the genesis and nature of the main ore-body, the cassiterite and accompanying minerals have not been included. The general statement has already been made⁽⁴⁶⁾ that the writer is of opinion that this group of minerals has been introduced at a later stage and by a distinct process from that of the replacement processes of the main ore-body. The evidence in favour of this view will be here summarised and briefly discussed.

(1) Fissures carrying crystalline cassiterite are found cutting across the bands of ore-material and country-rock in various parts of the main ore-body. Several instances of this were noticed on the surface outcrop of the ore-body between the south-east adit and Tulloch Creek; cassiterite

⁽⁴⁵⁾ *Op. cit.*, 231.

⁽⁴⁶⁾ Page 71.

was sometimes accompanied by pyrite, and generally by quartz.

In the section exposed by the No. 2 trench, where Tulloch Creek crosses the ore-body, cassiterite was noted in magnetite, evidently occupying an irregular fissure. This occurrence has previously been described.⁽⁴⁷⁾ In the No. 3 trench several cross-fissures were noticed in the magnetite zone carrying crystals of tin oxide, frequently associated with prismatic quartz.

Exactly similar occurrences were noted in trenches Nos. 4, 5, 6, and 7, where cassiterite occupied cross-fissures in banded magnetite.

It is a significant fact that several examples were noted in which cross-fractures were filled with crystals of prismatic quartz, with fluorite, or (less frequently) with black tourmaline.

Although in some cases no cassiterite was observed with these minerals, they are its known associates formed under similar conditions. In nearly every case where tin oxide was noticed it was closely associated with prismatic quartz. In some observed cases it was embedded in fluorite, and its association with that mineral is also borne out by microscopical sections. In a slide cut from a specimen collected in the No. 3 north crosscut from the south-east adit, in which cassiterite was not suspected, the microscope revealed the presence of quartz, chlorite, arsenopyrite, pyrite, siderite, fluorite, cassiterite, tourmaline, magnetite, and biotite. The fact of special interest and importance at this juncture is the occurrence of the cassiterite and associated minerals. Minute fissures traverse the groundmass of previously formed minerals, but these are now filled with quartz, fluorite, and cassiterite, and a little siderite is present. The cassiterite, as well as being present in these fissures, is noticed as scattered idiomorphic crystals in their neighbourhood, and from their occurrence partly in one mineral and partly in another, also partly included in several distinct crystals of the same mineral, it has evidently been introduced by these fissures, and has actually replaced some of the already consolidated minerals.

In other slides the tin oxide was seen to occur in scattered crystals and granular aggregates associated with tourmaline, although this association was not noticed in hand specimens.

(47) Page 73.

The occurrence of cassiterite with axinite has already been described.⁽⁴⁸⁾

These observations lead us to conclude that—

(2) The frequent association of cassiterite with other minerals recognised to be of pneumatolytic origin is strongly suggestive that the cassiterite has been introduced by the action of mineralisers.

(3) The occurrence of cassiterite in defined fissures, with idiomorphic prisms of quartz, and some pyrite, showing definite crustification, points to these minerals having been formed in some instances in open fissures. Occurrences of this kind have already been described.⁽⁴⁹⁾ The entire absence of magnetite, pyrrhotite, biotite, hornblende, and other replacement minerals so abundant in most parts of the ore-body is striking. It is inconceivable that such fissures could have been open at the time of the introduction of the replacement minerals, seeing that these minerals are absent. Hence the fissuring, although in some cases agreeing with the general strike of the sheeted zones, must have taken place subsequent to the formation of the main ore-body, and cassiterite introduced subsequent to its consolidation.

(4) The fact already noted⁽⁵⁰⁾ of the presence of cassiterite in irregular and sometimes intricate vughs is suggestive. The fact of its coating crystals of magnetite shows certainly that it must be later than that mineral. The writer believes these cavities to be due to decrease in volume due to changes in composition of the introduced mineral.⁽⁵¹⁾ If this supposition be correct, then the cavities could only be formed on the solidification of the main ore-body, and the cassiterite must have been subsequently introduced.

The evidence seems sufficiently definite to enable us to state that the *introduction of the cassiterite into the Mt. Lindsay ore-body took place at a time subsequent to the formation of the main deposit*, and that it owes its presence to pneumatolytic action, so-called “mineralisers” having been instrumental in bringing the mineral to its present position.

From the examination of a number of thin sections microscopically, and also of the ore-body *in situ*, and of

⁽⁴⁸⁾ Page 75.

⁽⁴⁹⁾ Page 82.

⁽⁵⁰⁾ Pages 81 and 87.

⁽⁵¹⁾ Page 86.

specimens collected therefrom, the following has been decided on as approximately the order of crystallisation of the more important minerals present in the ore-body:— (1) Magnetite, (2) hornblende, (3) pyrrhotite, (4) biotite, (5) garnet and pyroxene, (6) vesuvianite and wollastonite, (7) siderite and calcite in part, (8) quartz in part, (9) rutile, cassiterite, and tourmaline, (10) sphene and axinite, (11) pyrite and arsenopyrite, (12) calcite in part and fluorite, (13) chalcopyrite, (14) quartz in part, (15) calcite in part.

There may be some overlapping in certain cases, but the above order is probably approximately correct.

It remains for us to investigate the source whence the metallic lode-contents were derived.

In discussing ore-deposits of this type, under the heading of "Metamorphic Ore Deposits," MacAlister and Thomas (⁵²) state: "If an ore-body of magnetite occurs in an irregular manner in a rock containing garnet, diopside, and similar minerals, it is most probable that the metalliferous deposit was originally a metasomatic replacement of a limestone, and was deposited as the carbonate of iron."

And again, "Haematite and Magnetite: These two minerals among the iron ores, especially the latter, are of most frequent occurrence in metamorphic rocks, haematite being produced by the dehydration of limonite, and magnetite by the alteration of ferrous carbonate by loss of carbon dioxide, or by the partial reduction of haematite."

Mr. Montgomery also suggests a like origin for the magnetite deposits of the Comstock district. Referring to the New Silver Stream property (Sections 1642-87M, 3224-87M) he (⁵³) says: "The sedimentary rocks show strong evidence of contact-metamorphism, and it is probable that the magnetite in the large lode of this mineral . . . is due to metamorphism also, siderite or limonite having been changed to the magnetic oxide of iron."

Can the magnetite in the Mt. Lindsay ore-body, then, be derived from the ferrous carbonate, the carbon dioxide having been driven off by the heat engendered by the intrusion of the neighbouring granite?

(⁵²) "The Geology of Ore Deposits," by H. H. Thomas and D. A. MacAlister (1909), pp. 335, 336.

(⁵³) "Report on the Progress of the Mineral Fields of the County of Montagu," by A. Montgomery (1893), p. 17.

In this connection a recent paper by J. F. Kemp (⁵⁴) is of interest and importance as representing some of the latest views on the subject. He says (⁵⁵): "It [*i.e.*, metamorphism] would obviously be more frequently seen and more extensively developed with magmas rich in dissolved vapours. The crystallisation of these molten masses to the several anhydrous silicates which make up the final rock, drives out the dissolved vapours as magmatic waters, and provides thus a powerful agent of alteration along the borders. . . ." And again, (⁵⁶) "The commonest ore which is found associated with contact zones on limestone yields iron. The iron minerals magnetite and hematite seldom fail in any zone. . . . The iron ores seem to have been brought from the eruptive rock during its cooling stages by magmatic waters."

In dealing with the magnetite deposits of the Comstock district, (⁵⁷) Mr. Waller refutes this theory as applied to that district, being of opinion that the magnetite is primary. "With our extended knowledge of the distribution of the magnetite lodes and the carbonate of iron lodes on the West Coast, this theory has become untenable, for if it were true, we should expect to find large lodes of iron carbonate outside the metamorphic zone. Instead of these we find pyritic lodes with little or no iron carbonate. These certainly could not have been converted into magnetite by contact-metamorphic agencies." And again, "The magnetite is a primary mineral." (⁵⁸)

The writer is in full accord with this view as applied to the ore-body under review. *The magnetite here is primary; it does not represent the alteration of some previously existing compound of iron in situ, but has been introduced by highly heated gaseous solutions into previously-formed rocks, and by metasomatic replacement has replaced the original rock material.*

Granting that the iron oxide has been brought to its present position by solutions, and deposited there, from what outside source did these solutions derive their metallic contents? Two possible answers to this query suggest themselves: either from the sedimentary rocks themselves,

(⁵⁴) "Contact Deposits," by J. F. Kemp, in "Types of Ore-deposits," edited by H. Foster Bain (1911.)

(⁵⁵) *Op. cit.*, p. 191.

(⁵⁶) *Op. cit.*, p. 193.

(⁵⁷) "Report on the Iron and Zinc-Lead Ore-deposits of the Comstock District," by G. A. Waller (1903), p. 6.

(⁵⁸) Page 8.

or from the igneous magma which supplied the solutions. It is quite conceivable that the solutions, in traversing the highly-heated sedimentary rocks near the contact, have derived part of their metallic contents from those rocks, through which iron compounds certainly are distributed. It must be borne in mind that under conditions such as those to which we refer the solutions are extremely active, being in the state not of liquids, but of gases.

What seems more likely, and the opinion held by the writer, is that the magmatic waters have extracted their metallic contents from the magma before its consolidation. Being very energetic at this stage, the waters have been enabled to take into solution certain constituents of the original magma, and when expelled have carried these into the surrounding rocks and there deposited them when conditions were favourable, often (as we have seen) by a process of substitution for the material of the rocks into which they have been injected. Ascending through minute fissures, they have gradually replaced the rock on either side, depositing their dissolved metals and taking into solution material of the replaced rock, which, entering into new combinations, eventually goes to form new minerals.

It is possible that sulphur has been present in the solutions in considerable quantities in the earlier stages, and has greatly increased their activity. Waller⁽⁵⁹⁾ has suggested that magnetite may be accounted for by the reactions which take place between different sulphides of iron; thus:—



Perhaps under different conditions, *e.g.*, reduced temperature, some of the sulphides would consolidate as pyrrhotite and pyrite instead of magnetite.

Suppositions such as this are purely speculative. However, the essential genetic connection of the ore-body with the granite magma seems beyond much doubt. It is probable that the magnetite, hornblende, pyrrhotite, biotite, and lime-silicates were formed before the consolidation of the magma. At a slightly later period, at the final stages of consolidation of the magma, heated gases rich in volatile constituents which had been concentrated during consolidation were expelled, and rising through fissures formed fresh minerals, in some cases destroying others in

⁽⁵⁹⁾ *Op. cit.*, p. 6.

the process. It was thus that the cassiterite and accompanying minerals were formed.

In this case the question arises, why should cassiterite and its accompanying minerals be formed in the ore-body rather than in the surrounding rock? There seems to be a reason why we should expect to find tin-oxide and its associates here rather than in the surrounding country-rock. Reference has been made⁽⁶⁰⁾ to the probability of the formation of the lime-silicate group of minerals causing irregular cavities, from the fact that they occupy less space than the country-rock which they have replaced. If this be true, it has occurred to the writer that it would furnish a very good reason why cassiterite and its accompanying minerals should occur here. The fact of there being open spaces upon the crystallisation of the lime-silicates means that there is offered to the active, highly-heated gases and vapours forced out from the solidifying magma an easy way of escape, and they would ascend by this path, depositing their dissolved material under suitable conditions of temperature and pressure.

Of course, if fissures were available in the country-rock (and doubtless some such must have been), they would receive their quota, but the suggestion here offered presents (it is thought) a fairly sound reason why cassiterite should be expected in such an association as it is here found. It has also an economic bearing which will be discussed later.

An interesting point worthy of mention is the abundance of lime and magnesia bearing minerals in the deposit. The group of minerals referred to is very typical of contact-metamorphic deposits, but in most recorded instances the rock replaced is a limestone, or highly calcareous rock.

As we have seen, among the minerals present are garnet, diopside, vesuvianite, epidote, chlorite, actinolite, wollastonite, fluorite, axinite, calcite, also hornblende, tremolite, biotite, dolomite, and titanite. These are all lime or magnesia-bearing, not all contained in the ore itself, some of them only being noticed in residual bands of country-rock, which may be quite enclosed in ore material. The presence of so many members of the group of "lime-silicates" is striking, and this fact, taken in conjunction with the association of abundant magnetite, would lead one unfamiliar with details to assume that we were dealing with a replacement ore-body in limestone.

(⁶⁰) *Vide* page 86.

As already noted, this is not the case. There is no evidence to show that the enclosing sediments are high in lime contents. It is unfortunate that analyses of these rocks and minerals have not yet been made. In consequence, one is scarcely justified in forming definite conclusions. However, the fact appears to call for some comment.

If the assumption that the country-rock of the locality does not carry a high proportion of lime and magnesia is justified, then it is evident that these materials must have been introduced in solution from some external source. One occurrence of interest, and seeming to point to the fact that the minerals have been derived from material introduced in solution, is that in the No. 2 south crosscut from the south-east adit.

Here about 12 inches of slate with green chlorite, and showing garnet and vesuvianite, is succeeded by a band of irregular width, averaging about 15 inches, apparently composed entirely of radiating black hornblende, with irregular patches of green chlorite and of granular garnet. Microscopically a little scattered magnetite is seen to be present, while the hornblende is so choked with iron oxide as to be practically opaque. Separated from this by about 12 inches of thoroughly decomposed slates, now bluish and white clay, is a vein-like band varying in width up to 12 inches composed almost entirely of crystals of vesuvianite of small size, in single crystals and groups of crystals. The walls are sharply defined, and are coated by crystals of the same mineral, with sometimes idiomorphic prisms of quartz. Traversing the vesuvianite mass are one or two small irregular fissures filled with quartz crystals. The mass of vesuvianite is non-coherent, and can be crumbled between the fingers, owing probably to some constituent having weathered out of the groundmass. This band of vesuvianite is bounded on the southern side (as well as the northern) by soft white-banded clay, here about 6 inches in width, followed sharply by 3 feet 6 inches of very hard fresh slates, showing some disseminated pyrite. This belt is again bounded by a narrow band of very soft decomposed banded clay, about 1 foot from the face of the drive. This 12 inches is of massive, very tough, reddish-grey rock, apparently composed of patches of pink garnet irregularly distributed through a groundmass of grey limestone, with occasional veinlets filled with crystallised calcite. A thin section of this rock examined microscopically shows the presence of garnet, calcite, diop-

side, vesuvianite, and epidote. The garnet is in granular masses, interstices being filled with calcite. The calcite occurs generally in masses of grains showing typical aggregate structure; also in crystal plates enclosed in granular garnet, and filling small fissures which cut through the masses of garnet. Idiomorphic crystals of diopside of granular habit are present, frequently included in the calcite, and also enclosed in granular garnet. A little epidote and vesuvianite occur in scattered grains. The width of this band of rock is unknown. It occupied the face of the crosscut at the time of the writer's examination.

The occurrence of so many lime and magnesia-bearing minerals in this crosscut is of special interest when considered in conjunction with occurrences in other parts of the mine.

In looking round to try and determine the source of this lime and magnesia, one naturally turns attention first to the original magma whence the magmatic waters which formed the ore-body were expelled. But an examination of the neighbouring granite ⁽⁶¹⁾ reveals nothing which can justify our assuming that the magma was abnormally rich in these constituents. Hence we must look elsewhere. If the solutions did not carry a high lime and magnesia content when they commenced their upward journey from the magma, nor derive it from the rocks in which the minerals concerned now occur, obviously the addition of lime and magnesia must have taken place at some intermediate point.

Reference may here be made to a discussion of this question by Mr. L. K. Ward in a recent valuable and suggestive paper,⁽⁶²⁾ where various occurrences are dealt with in a much more comprehensive manner than can be attempted here. Mr. Ward describes—

Diopside and chlorite rocks from the Comstock region and Anderson's Creek (near Beaconsfield);

Axinite-actinolite-calcite rock (limurite) from the Colebrook Mine; and

Garnet-vesuvianite-actinolite rock from Gormanston Creek, North Dundas.

He deals with the mode of occurrence of these rocks, remarking that, with the exception of the chlorite rocks,

⁽⁶¹⁾ For description *vide supra* pp. 26 to 32.

⁽⁶²⁾ "The Origin of Certain Contact Rocks with a High Content of Lime and Magnesia," by L. Keith Ward, B.A., B.E. (Proceedings of Section C, Australian Association for the Advancement of Science, Vol. XIII.).

which "are found at Anderson's Creek, near Beaconsfield, actually within the boundaries of the serpentine and pyroxenite of that district . . . the remaining groupings are almost invariably found within sedimentary terrains, but without exception in the immediate vicinity of basic igneous rocks, either identical with or closely related to those which have been observed at Anderson's Creek."⁽⁶³⁾

As a result of his investigation into these various occurrences in detail, Mr. Ward puts forward a theory to account for them. He says⁽⁶⁴⁾: "The point which it is desired to make is that the fissures or paths whereby the emanations from the granitic magma have ascended cannot but traverse the basic igneous rocks through some portion of their subterranean course, even when they are now seen at the surface to lie within the boundaries of rocks which have a sedimentary origin. It is to the chemical reaction of the emanations from the acidic magma hearths upon the walls of fissures which traverse the basic rocks that the author would ascribe the greater part of the lime and magnesia contents of the contact-rocks here described."

The occurrence at Mt. Lindsay is not quite parallel with those considered by Mr. Ward. The same essential genetic connection with acid igneous intrusives of Devonian age is maintained. The fact that basic rocks occur, similar to those described in other localities and of a slightly earlier period than the acidic rocks also holds true. But a glance at the accompanying geological map of the district⁽⁶⁵⁾ will show that, whereas the nearest known *outcrop* of basic rocks is over 1½ mile horizontally, the granite outcrops within about 10 chains of the extension of the ore-body, as proved by Messrs. Conroy and Roberts. Since the edge of the granite is apparently dipping at a moderately flat angle (as indicated by the width of the contact-metamorphic aureole), and since the granite is of later age than the basic rocks, it is difficult to see how the solutions which emanated from the granitic magma can have traversed basic rocks.

For the present the matter cannot be finally decided. Until a careful series of chemical analyses proves him wrong, the writer prefers in this instance to regard the sedimentary series of slates, tuffs, sandstones, and porphy-

⁽⁶³⁾ *Op. cit.*, p. 181.

⁽⁶⁴⁾ *Op. cit.*, p. 184.

⁽⁶⁵⁾ Plate II.

roids as having furnished most of the lime and magnesia to the solutions which have traversed them, to enable the group of minerals under discussion to be formed. A certain amount would probably be obtained from the magma.

As this type of deposit is unusual, and has not been previously described in any detail in Tasmania, brief references will be given to one or two foreign occurrences of similar nature, for sake of comparison.

Under the heading "Contact Metamorphic Ore Deposits," in his "Nature of Ore Deposits," Beck⁽⁶⁶⁾ describes "The Iron Ore-deposits of the Schwarzen and Gelben Krux, Germany":

"A tourmaline-bearing granite, carrying allanite and fluorspar near the ore-deposit, has broken through Cambrian clay slates. Near the Krux mines the slates are transformed about the contact into hornstones, which at some points are characterised by cordierite, tourmaline, and garnet; at others by andalusite and sillimanite. Tourmaline-bearing quartzites also occur. The magnetic iron ores . . . belong to this contact zone. Their granular crystalline mass always has fluorspar mingled with it, often also wolframite, molybdenite, hematite, allanite, barite, and pyrite. Sometimes a good deal of quartz is added. From one of the abandoned shafts greenish-yellow garnet rocks were also obtained, with intermingled calcite, barite, feldspar, and magnetite. B. von Cotta mentions a tin-content in the ores. We are of the opinion that the ore-deposits were derived from a contact-metamorphic mineralisation of calcareous intercalations."

It will be seen from this description that, although there are some minerals present which have not been recorded from Mt. Lindsay, these two ore-bodies have some striking features in common.

In the same chapter of the work quoted,⁽⁶⁷⁾ Beck briefly describes the characteristics of "The Contact Deposits of the Christiania Region." He says: "Most of these deposits are intercalated approximately parallel to the stratification of the slates and limestones. Many are cut by tongues of the granite intrusions and dykes of quartz-porphyry and of various granites, proving that they were formed before the last phase of eruptive activity had closed. The country-rock shows intense normal

⁽⁶⁶⁾ The Nature of Ore-deposits," by Dr. R. Beck, trans. W. H. Weed First Edition, Vol., p. 587.

⁽⁶⁷⁾ *Op. cit.*, p. 594.

contact-metamorphism, with the formation of new garnet, vesuvianite, scapolite, biotite, pyroxene, hornblende, epidote, chialstolite, &c. The ores, which have not only replaced limestone, but even more frequently slate, consist of the oxides of iron with subordinate amounts of copper pyrite, argentiferous galena, blende, iron pyrite, arsenopyrite, smaltite, bismuthinite, and molybdenite. Calcespar, fluorspar, apatite, garnet, epidote, rarely also axinite and helvine, accompany the ores. Thus even the iron deposits show examples characteristic of the tin deposits."

Here again the cases are not quite parallel, but the essential features are similar.

To come nearer home, we have in the Comstock region, about 4 miles west of Zeehan, magnetite deposits which appear to have many characteristics in common with the one under review. The writer has not yet had an opportunity of visiting this district, but culls the following general particulars from Mr. Waller's report.⁽⁶⁸⁾

The magnetite deposits are abundant in the district, being typically developed at the contact of intrusive granite [Devonian, L.L.W.] with Silurian strata, or in the vicinity of the contact, never in the granite itself. They are sometimes found at the contact of gabbro [Devonian] with Silurian strata, or perhaps within the gabbro or serpentine, but the granite-contact is never far distant. The minerals observed are magnetite, pyrite, chalcopyrite, arsenopyrite, galena, zinc blende, cassiterite (in one instance at the St. Dizier Mine), diopside, lime-silicate hornstone, tremolite, actinolite, garnet, epidote, vesuvianite, chlorite, phlogopite, talc, serpentine, calcite, quartz, manganeseiferous siderite. Mr. Waller discusses the possibility of the derivation of the deposits from the basic rocks, but is of opinion that they are contact-metamorphic deposits connected with the granite rather than with the gabbro.

Under the heading of the Stanniferous Contact Metamorphic Deposits is probably to be classed the gossan formation in the north-western corner of Section 133M. A few remarks seem called for to explain the occurrence and the reason for its classification here.

A description of the occurrence is given in another part of this report.⁽⁶⁹⁾ It will be seen from what has been

⁽⁶⁸⁾ "Report on the Iron and Zinc-lead Deposits of the Comstock District," by G. A. Waller (1903).

⁽⁶⁹⁾ *Vide* page 141 *et seq.*

said there that so little work has been done that the nature of the primary ore is rather a matter of conjecture than certainty, as the latter has not been exposed, and hence a description of the mineral association is impossible.

It appears that the deposit is a true contact one. At some points, at any rate, the gossan appears to be separated from the granite only by a selvage of kaolin. The banded clays referred to, sometimes stanniferous, would seem to be altered sedimentaries, belonging probably to the series extensively developed west of the Stanley Reward, and of the Four-mile Creek,⁽⁷⁰⁾ and which has tentatively been classed as of Pre-Cambrian age, though the matter of age is still quite open to question.

The deposit occurs, then, at the junction of granite of Devonian age, intrusive into slates of probable Pre-Cambrian age.

The ore itself is essentially limonite and haematite, with disseminated cassiterite. It varies a good deal in texture. Frequently quite open and cavernous, there are sometimes bands of massive haematite, sometimes hard bands of what are evidently clay ironstone. The general banded appearance is striking, suggesting that here, as in the case of the Mt. Lindsay Mine, we may have a replacement ore-body, in which bands of country-rock have been replaced by mineral. The banded clays, with red iron oxide marking the bands, appear to represent original slate bands, into which pyritic material has been introduced along the cleavages, but in which the bulk of the rock has not been replaced. It is significant that where this mineralisation ceases the clays cease to carry tin. The occurrence of tremolite here is worthy of notice. Occurring apparently in rather irregular veins, it was noticed in the white clays exposed in the company's workings on the eastern side. It is pure white, and not easily distinguishable from the clays excepting on close examination, when it is seen to consist of a mass of crystalline aggregates, now soft and partly decomposed. Before the blowpipe it reacts for magnesia, lime, and silica. It is doubly refracting under the microscope, and shows extinction angle up to 20 degrees between crossed nicols. Occurring in the gossan (specimens being obtained from the west side, at the tributers' workings), is a reddish-brown mineral occurring in aggregates similar to that just described, masses of 5 inches in thickness being obtained, although its mode of occurrence could not be

(70) *Vide* Plate II.

seen in detail. It is probable that this, too, represents tremolite (much iron-stained) which has crystallised with sulphide, now thoroughly oxidised. This is said to carry no traces of tin whatever.

In some places in the gossan a little black botryoidal haematite was noticed.

Magnetite is not as abundant as one would expect in an ore-body of this nature, but it certainly is present, often in disseminated crystals through the gossan, one specimen showing a distinctly columnar structure.

An important feature, as throwing light on the nature of the ore-body and probable developments at depth, is the presence of a little decomposing pyrite in the gossan. The presence of crystals showing combinations of octahedron and pyritohedron, and octahedron and cube is referred to in another place.⁽⁷¹⁾

From the outcrop described as occurring on the western boundary of the section,⁽⁷²⁾ specimens were obtained consisting of groups of perfect crystals from $\frac{1}{4}$ -inch to $\frac{1}{2}$ -inch in size, the only crystal form represented being the diploid. Although retaining their crystal form and appearing on the surface to be fresh, on fractured faces these crystals were seen to be much decomposed.

Specimens collected from the tributers' workings showed fine pyrites, a good deal decomposed, but still recognisable, in alternating seams with hard clay ironstone.

This evidence points conclusively to the fact that the formation will become pyritic (and probably highly so) at no great depth.

Cassiterite appears to be well disseminated through the gossan, where it does occur, and not in well-defined seams and fissures. In some places it is very noticeable, the crystals standing out boldly from the weathered surface of the gossan.

The association of granite porphyry, and particularly of veins of quartz and of tourmaline in portions of the formation, undoubtedly stanniferous, are significant facts. The data is insufficient for a full discussion of the mode of origin, but the facts suggest that the occurrence may prove similar in general respects to the Mt. Lindsay ore-body, and that, as in that case, so here, the cassiterite may have been introduced by pneumatolytic agencies into a previously formed normal contact-metamorphic deposit.

⁽⁷¹⁾ *Vide* page 144.

⁽⁷²⁾ *Vide* page 141.

It is only in the light of future developments that this matter can be discussed.

B.—LEAD AND ZINC ORES.

As in the case of the pyritic cassiterite deposits, no definite lead zinc ore-body has been positively proved on the field, but brief reference must be made to what is almost certainly an ore-body of this type. The finding of numerous loose pieces of galena and galena-blende-pyrite in the wash when sluicing at the Stanley Reward led to a search being made, and it seems that at one particular point large masses of these minerals were found, and beyond it none. Although certainly in the decomposed dolomite, absolutely no prospecting work has been done to prove whether it really is *in situ*, as it appears to be. There are strong reasons for believing that an ore-body does exist here.

Galena, zinc blende, and pyrite are apparently the only minerals present in the specimens. No cassiterite is present in samples submitted for assay.

It is quite possible that this may prove to be a pyritic cassiterite deposit, as the type carries galena and blende. Beyond recording the fact of this occurrence, little more can be said at the present stage.

From the occurrences noted in the "pug," the strike would appear to be about N. 60° W.

About 50 feet east of this there appears to be another lode, essentially pyritic, with an apparent strike of N. 10° W.

C.—IRON ORES

Reference must be made to the possible occurrence of iron ores of economic value in the district. In the writer's opinion no iron ores of economic value have been proved in the district up to the present time.

One occurrence which should be worth investigating with improved means of transit and a demand for iron ore is that occurring at the foot of Mt. Livingstone, near the head of the Livingstone Creek Flat. It outcrops in the south-eastern corner of Section 4958M, and extends across the southern boundary into Section 4977M. The deposit is still undeveloped, and at this stage a definite opinion can scarcely be expressed.

The outcrop rises abruptly to about 30 feet above the flat, forming a low ridge, generally covered with thick

scrub. Into this two small prospecting adits have been driven, one 65 feet and the other 85 feet. The width of the outcrop is not fully exposed, but appears to be about 2 chains. The length over which a little occasional work has been done is about 10 chains, though some points are still thickly covered with scrub.

The material consists mainly of banded and of radiating haematite with some magnetite and limonite.

The appearance of the ore is striking. It consists of radiating spherulitic aggregates, from $\frac{1}{4}$ -inch to $1\frac{1}{2}$ inch in diameter, circular in section, with aggregates radiating from a centre; also of masses of prismatic aggregates up to 3 inches in length, with always a tendency to radiating structure, but not forming complete spheres, these prismatic aggregates crossing and recrossing each other in all directions. The small spherulitic masses consist essentially of magnetite, with some haematite, and with yellow limonite occurring interstitially between the blades and between the aggregates. These masses are frequently stained greenish, probably by the presence of a small amount of some chloritic mineral. The larger spherulitic masses, of about $\frac{1}{2}$ to $1\frac{1}{2}$ inch, are brown haematite, with interstitial limonite as before, and in places a little magnetite. The large prismatic aggregates are reddish-black haematite, with a little interstitial limonite and rather coarse grains of magnetite. Masses of granular magnetite occur in places, while frequently the formation is distinctly banded, bands of hard clay ironstone occurring, sometimes evidently replacing country-rock, and showing included quartz grains.

In one place, a few feet north of the adit driven in Section 4958M, some irregular seams of soft white saccharoidal quartz occur, apparently dipping west, cut through in all directions by veinlets of black manganiferous haematite.

The whole mass strongly affects the magnetic needle. It is very close to the contact of the granite with schist, but appears to be in the latter country-rock. It is evidently a contact-metamorphic ore-body, but little can be said of what the primary nature of the deposit is likely to be until a little more prospecting work has been done. The striking radial haematite is unusual. The mineral does sometimes occur radiating, however, for Dana⁽⁷³⁾ says, under the heading of compact columnar haematite:

(73) "A System of Mineralogy," by J. D. and E. S. Dana, 6th Edition, 1906, p. 215



PHOTO. 4.—Radiating Hematite, probably Pseudomorphous after Tourmaline: Section 4958M., Stanley, River.

[L. L. Waterhouse, Photo.]

“The masses are often long radiating; lustre, submetallic to metallic; colour, brownish-red to iron black.” This description certainly describes the mineral occurrence here.

However, instead of regarding it as a primary, the writer is more inclined to regard the haematite as a secondary mineral, resulting from the alteration of, and occurring as pseudomorphs after some other mineral. Mr. Montgomery suggested that the original mineral, now altered, was tourmaline. The structure is certainly very characteristic of tourmaline, and a comparison of specimens from this deposit with some unaltered black tourmaline aggregates from the contact deposit shown on the accompanying map as occurring on the western boundary of Section 4772M, shows how similar the structure is in the two cases. Repeated tests were made, but no trace of boron could be detected, nor can any record be found of haematite occurring as a pseudomorph after tourmaline.

It is possible that amphibole may be the primary mineral. It occurs in these forms, it is known to alter to the iron oxides, and it is present in considerable quantities in some of the contact deposits of the district. With our present limited knowledge of the occurrence, the final determination must be postponed.

The small amount of prospecting work carried out seems to have been with the object of testing for tin. So far as I was able to learn, none was detected. A sample sent to the Government Analyst contained no tin. Nevertheless, it is quite possible that cassiterite may be present, and prospecting is rather to be commended, for it has been seen that the contact deposits in other parts of the district do contain tin, sometimes in what is believed to be payable quantity.

The deposit has been tentatively classed with the iron ores. So far as is known at present, it contains no other minerals of economic value. The full extent of the body is not known. It is apparently of considerable size and fair quality. Although no really deleterious elements appear to be present, it must be remembered that the oxidised surface outcrop only is available for inspection. From the fact of its being a contact-metamorphic deposit formed under exactly similar conditions to the other contact deposits described, all of which carry sulphides, it seems likely that this deposit, too, at no great depth will be found to carry sulphides.

From the point of view of exploitation, insufficient backs are available to allow of economically opening up by adits; it would have to be worked from an open-cut or shaft.

Under present conditions of demand for such a product, and with the difficulties of transport, the deposit cannot be classed as one of commercial importance.

(4)—THE ALTERATION OF THE WALL-ROCKS OF THE LODES
BY THE MINERAL-BEARING SOLUTIONS.

This feature of the ore-bodies has already been dealt with to some extent in discussing the various types of deposits, and this section will serve partly as a summary, with the addition, however, of fresh facts in several instances.

The student of ore-deposits is forcibly struck by the differences in the alterations of the wall-rocks of various ore-bodies, differences not only of kind, but also in extent. In some instances no change is apparent, beyond perhaps a slight hardening, while in others the original rock is entirely broken down, and altogether new minerals formed. The outstanding factors governing both the nature of the alteration and its extent seem to be—

(a) The composition of the vapours or solutions (some substances being far more active chemically than others).

(b) The composition of the rocks undergoing change (some being far more resistant than others to alteration).

(c) The temperature at which the change takes place.

As these factors may vary from point to point, we should expect the wall-rocks to be differently altered in various ore-bodies even in the same district. This proves to be actually the case.

Where veins of the quartz-tourmaline-cassiterite type occur in granite, considerable alteration has taken place. The attacking solutions have evidently been rich in boron compounds, and to their attack the feldspars and biotite of the already consolidated granite have succumbed. As a result of the action, tourmaline has been formed, and fresh quartz. Hence we frequently find, as well as tourmaline aggregates in the groundmass of the altered granite, perfect pseudomorphs of tourmaline after feldspar. The outlines of the original feldspar crystals remain very sharply defined, but the interior of the crystals is converted to a mass of minute radiating aggregates of needle-like crys-

tals of tourmaline (generally green); instead of tourmaline only, we sometimes find tourmaline and quartz, tourmaline and cassiterite, or occasionally cassiterite only. Some muscovite also occurs.

In the case of Castle's vein described,⁽⁷⁴⁾ it was noticed that the granite seemed soft and decomposed to an exceptional degree for some distance on either side of the vein. This is probably due to the development of kaolin by the action of carbon dioxide (introduced in solution) on the feldspars.

Although the alteration is so marked in the case of the granite, generally where the wall-rock was slate the alteration was comparatively slight (regarding quartz-tourmaline dykes as simply a variation of the quartz-tourmaline-cassiterite type, for none of the latter were observed in slate in the district). A slight silicification and tourmalinisation, with hardening, were the only noticeable effects.

The alterations of wall-rock in the case of the contact-metamorphic deposits has already been rather fully described. Remembering that the rocks have been considerably altered by the intrusion of the masses of igneous rock, even apart from the action of the ore-bearing solutions, and that in addition to this widespread alteration, forming a contact-metamorphic aureole, the ore-bearing solutions have been active and have superimposed other changes, the difficulty of ascribing each type of alteration to its true source will be realised. Again, it is scarcely necessary to remark that the alteration in each case is probably of a kindred nature. It is likely that whenever a huge mass of granite intrudes sedimentary rocks, much of the alteration induced in the latter is not due to heat alone. The vapours and solutions set free probably exert a potent influence in this direction, although it is only under favourable conditions that ore-deposits will be formed.

In the case of the Mt. Lindsay Mine, it has been shown that the ore-body has been formed by a gradual replacement of the country-rock. This replacement is sometimes complete, so that although the structure of the rock may be retained, none of the original rock remains, or it may be that the replacement is only in its incipient stages. Hence, the variation in the alteration of the country-rock is considerable. One or two outstanding features may be here remarked on.

(74) Page 64.

The development of lime-silicates is remarkable. The amount of garnet and accompanying minerals present in the residual bands of country-rock has been remarked on. Frequently vesuvianite is exceptionally well developed. For example, in the No. 2 north crosscut from the western adit masses of stout translucent prisms of square and octagonal cross-section, up to 8 mm. in section by 12 mm. long were noticed, with apparently a good deal of garnet developed in the groundmass of the rock.

The interesting occurrence in the No. 2 south crosscut from the south-east adit has already been described.⁽⁷⁵⁾

As the subject of the lime and magnesia bearing minerals of the ore-body has already been discussed,⁽⁷⁶⁾ nothing further need be said here.

Another way in which the walls have been affected has been by the development of pyrite. Both in disseminated crystals and occupying minute intersecting fissures, pyrite is very common in the wall-rocks.

The development of actinolite and of biotite was frequently noticed.

In all cases there has been an extreme hardening, due frequently to the introduction of silica.

At several points tourmaline was found to be developed, forming narrow veinlets of needle-like black crystals, replacing probably argillaceous bands of the slates.

(5)—THE STRUCTURE OF THE LODES.

This question has already been dealt with in the case of the contact-metamorphic deposits, and little remains to be said here. They are banded deposits, caused through the replacement of bands of country-rock by ore and gangue minerals introduced in solution through a series of lode-fissures, *i.e.*, parallel fissures, sometimes closely spaced, sometimes rather wider apart. The result of this action has been that a number of sheeted zones have been formed. Bands of unreplaced country-rock remain included in the ore-body.

In the stanniferous type, cassiterite with boron and fluorine bearing minerals have been introduced by pneumatolytic agencies into the more or less porous ore-body formed by the method just indicated.

If this supposition with regard to the mode of origin of the ore-body be correct (and the evidence in favour of

⁽⁷⁵⁾ Page 94.

⁽⁷⁶⁾ Pages 93 to 97.

it appears to the writer to be conclusive in regard to the Mt. Lindsay ore-body), it has an important bearing on the prospects of permanence of tin values to depth.

Contact deposits as a rule are somewhat irregular, and work in different parts of the world has shown that frequently they do not continue to any great depth. If followed down, the main magnetite body would probably be found to cut out when the contact between slate and granite was reached. The point which the writer would emphasise, however, is this:—*The tin values are likely to be permanent, and to extend not only to the granite junction in depth, but beyond it into the heart of the granite mass itself.*

Another point worthy of note with regard to structural features is that of disturbance since the formation of the ore-body. Too little is known of the deposits other than that of Mt. Lindsay to enable statements to be made in general for the class, but the prospecting already carried out at Mt. Lindsay has revealed the presence of at least one fault.⁽⁷⁷⁾ This appears to strike N. $55\frac{1}{2}^{\circ}$ E., and dips towards the south-east. The country-rock is much fractured at this point, although the effect of the disturbance on the ore-body was not evident at the time of inspection, the drive not being continued far enough to expose the ore-body proper. In a letter received a short time ago Mr. O'Brien, the mine manager, stated: "It is impossible to give an exact idea of the amount of displacement. I should estimate the actual amount of displacement at about 70 feet. The ore-body where intersected is composed of biotite-magnetite, with disseminated pyrite and small thread-like veins of calcite."

Obviously the fracture has occurred since the formation of the ore-body. The intrusive granite porphyry dyke appears to have been displaced as well as the ore-body. This faulting is not likely to seriously affect economic mining. Fracture-planes were noticed also in the south-east adit, and in the western adit; but these have apparently not disturbed the ore-body to any extent, and are of little importance. In each case they acted as water-channels.

The topography exposes a section of about 300 feet of the ore-body, and no change in structural features is noticeable between the highest and lowest exposures.

(77) *I*de Plates II. and VI.

With reference to the quartz-tourmaline-cassiterite type of veins, little more need be said here, the structure having already been explained.

In one case, that of "Castle's vein," the small amount of work done shows that the tin-bearing vein has been considerably dislocated by movements which have taken place in the granite itself since consolidation. Here the vein has been so disturbed that its value as a likely producer of tin on a commercial scale is seriously impaired.

(6)—THE SECONDARY ALTERATION OF THE LODES.

In the case of the quartz-tourmaline-cassiterite veins, the effects of secondary alteration seem to be that a simpler class of ore has resulted. Reference has been made to the fact that, although sulphides are commonly present in this type, they seem to be almost entirely wanting in this district. In one instance only, where a vein of quartz-tourmaline was observed in the contact sedimentaries in Section 4771m, intersected by a small race cut by Messrs. Conroy and Roberts, was pyrites observed in a vein of this type. Although not known to be stanniferous, the vein referred to, about 2 feet wide, with a strike N. 65° W., and a dip south-westerly at 70°, carries a good deal of pyrite, partly weathered and decomposed.

It is very probable that the simple nature of most of these veins near the surface is due to secondary alteration, and that they will nearly all be found to be pyritic at depth.

The alteration of the contact-deposits has been considerable, with the result that the economic value of the deposits has been increased, not from any enrichment by solution and deposition of material of economic value, as sometimes happens, for example, in the case of copper ores, but rather owing to the removal in solution of materials which may render the ore more complex.

In the case of the Mt. Lindsay Mine we have an occurrence which is rather puzzling. The ore-body is dissected by Tulloch Creek, which flows in a general southerly direction, and has cut a valley for itself, which is still geologically young, and consequently has steeply sloping sides. The ore-body crosses from spur to spur. To the west the Mt. Lindsay spur rises to 370 feet above the creek, while to the east, the south-east spur is only about 130 feet above the same point. The ore-body has been traced across the Mt. Lindsay spur, and down its western slope towards

New's Creek, to within a few chains of the granite contact. It outcrops on the western slope of the south-east spur, but has not been definitely located on the eastern slope.

This brief description is necessary to make clear the following discussion.

A very striking feature is the occurrence of a considerable body of gossan on the eastern side of the creek (*i.e.*, on the western slope of the south-east spur), while on the opposite side of the creek (eastern slope of Mt. Lindsay spur) dense sulphides occur practically at the surface. There is a little gossan towards the crest of the ridge and on the western slope.

Why should the ore be so profoundly altered in character on one bank of the creek while remaining perfectly fresh a few yards away on the other bank, the oxidation having apparently been confined to a surface crust of limonite 1 to 2 inches thick? The character of the gossan resulting from the oxidation of the south-eastern ore-body, as it is called locally, must be referred to. It is quite of normal character, consisting essentially of limonite and haematite of a general reddish-yellow colour. It retains the general banded character so typical of ore from practically all parts of the mine; it is generally very porous, but has hard bands of clay ironstone of varying widths, resulting from the oxidation of the residual slate bands described as occurring so often in the ore-body, and their impregnation with limonite. A striking feature is the occurrence of fissures containing prismatic crystals of quartz, and sometimes cassiterite. These have previously been described.⁽⁷⁸⁾ The absence of these fissures lined with quartz from the sulphide-body is almost as marked as their presence here. Quartz does occur in other parts, but apparently more sparingly. In one instance where a similar occurrence was noted, in No. 4 trench, it was associated with gossan also. A similar association was noticed in the western adit workings.

The writer is of opinion that these fissures with crystallised quartz partly account for the formation of gossan in one part and not in another to the same extent. They would form excellent channels for surface waters to soak into the ore and exercise an oxidising effect on the sulphides present. This theory receives some support from an actual example noticed in the south-east adit, where a

(78) *Vide* page 82.

good deal of water was finding its way down one such vein. In the case of the parts of the ore-body where such water-channels did not exist, oxidation would naturally be much slower, extending from the surface downwards. The actual amount of water penetrating the ore-body, which is very dense, would be small.

Undoubtedly the formation of the gossan has been assisted by the presence of fracture-planes. Several such were noticed in the south-east adit and the western adit, and in each instance they were acting as water-channels.

Doubtless the formation of gossan on the south-east spur has been partly assisted by the topography. This spur not only slopes less steeply to the creek, but the summit is flat and of considerable width compared with that of the Mt. Lindsay spur, being several chains across. Water would tend to lodge here to a greater extent than on the opposite spur.

The south-eastern gossan-body is stanniferous. There may have been a certain amount of purely *mechanical* concentration of cassiterite in some of the more open fissures, but no process of solution and redeposition has taken place. The oxidation and removal in solution of most of the pyritic material has left many cavities in the residual gossan, which is therefore very much lighter, **bulk** for bulk, than the original sulphide body, whose place it takes. Consequently, although the actual *amount* of tin oxide present in the gossan is exactly the same (with the exception of the slight amount of mechanical concentration referred to) as that which was present in the sulphide body before oxidation, yet the *percentage* of tin oxide will have considerably increased.

If any attempt be made to form an estimate of the value of sulphide ore from the known value of the oxidised ore (as is sometimes done), the point here emphasised should be borne in mind.

A few other minerals occur as a result of the secondary alteration of the lodes. Melanterite and chalcantinite, the hydrous sulphates of iron and of copper respectively, are fairly abundant as efflorescent deposits derived from the decomposition of the sulphides of iron and of copper. A little of the green carbonate of copper, malachite, was also noticed at intervals in the gossan. This also has been derived from the decomposition of chalcopyrite in the ore, as have been the deposits of minute thin plates of metallic copper noticed on cleavage-planes of the slates in the oxidised portion of the ore-body. Pyrolusite, the black oxide

of manganese, was noticed in velvety crusts in some of the gossan cavities of the western adit of the Mt. Lindsay Mine.

At the Stanley Reward, in the bottom of the alluvial workings, some tree-roots were found encrusted with vivianite, blue phosphate of iron, derived from the alteration of iron-bearing minerals.

(7)—THE SECONDARY ORE-DEPOSITS OF THE DISTRICT.

A.—TIN ORES.

This portion of the report should be read in conjunction with the chapter dealing with the mining properties.⁽⁷⁹⁾ It is intended that the latter shall deal rather with a description of the properties, while the present section refers essentially to the nature and mode of origin of the tin ore.

If one were to judge by the market-value of the ore produced, the secondary tin ores of the Stanley River district are easily the most important. It was the presence of alluvial tin which first called attention to the district, and it was only after deposits of this nature had been prospected that any attempt was made to discover whence the alluvial tin was derived.

The most important deposit in the district is certainly that contained within the boundaries of Sections 133M and 134M, each of 80 acres, charted in the name of R. W. Maskell, and owned by the Stanley Reward Tin Mining Company, No Liability. The situation of these sections will be seen by a glance at the general map accompanying this report.⁽⁸⁰⁾

The tin won may be divided approximately into two classes, (*a*) coarse tin ore, in the form of nuggets and specimen pieces of lode material; (*b*) fine tin oxide, in the form of separate crystals and minute granular aggregates. It is scarcely necessary to say that no hard and fast line can be drawn between the two classes.

The coarse tin is shed from lode-formations of the various types described. Of these, the quartz-tourmaline-cassiterite type furnishes probably by far the largest share. Many of the specimen pieces are well rounded, while others are sharply angular, and have evidently not travelled very far from their source, or been long subject to the pounding and grinding action in the water-courses. Naturally

⁽⁷⁹⁾ *Vide* page 129 *et seq.*

⁽⁸⁰⁾ *Vide* Plate II.

metallic and gangue minerals are present in all proportions. Many of the pieces are quartz-tourmaline boulders with some cassiterite, while others again are masses of granular or crystallised cassiterite with a little quartz-tourmaline gangue. Many rounded nuggets of cassiterite up to about 1 inch in diameter were seen, with apparently no gangue minerals at all present. These, too, appear mostly to have been derived from disintegration of the quartz-tourmaline-cassiterite veins.

One of these nuggets of apparently pure tin oxide was sectioned and examined microscopically. It was seen to consist of a granular mass of brown cassiterite, traversed by veinlets filled with more coarsely crystalline cassiterite, with fairly abundant small idiomorphic prisms of tourmaline, often completely included in cassiterite crystals. Throughout the mass are minute fragments of allotropic quartz, evidently filling the interstices between the previously crystallised cassiterite.

This bears out the contention that even when no gangue minerals can be detected, the masses of granular tin oxide are only disintegrated portions of lode-matter, sometimes at least of the quartz-tourmaline type.

When tourmaline is present, the green variety is always represented, although the black may be present as well. Sometimes the tin oxide is scattered through a quartzose groundmass, without visible tourmaline; in one such specimen some muscovite mica was noticed.

The nuggets of tin are usually black or dark-brownish-black, but Mr. Gould, a prospector on the field, kindly gave the writer two pieces (the larger about 1 inch across) of well-rounded massive light-yellow cassiterite, showing no signs whatever of crystalline structure or of any gangue mineral. Chemical and physical tests showed conclusively that the specimens were really cassiterite of good quality.

The finer grade of tin oxide won is seen to consist largely of individual crystals of black, or sometimes brownish, colour. Sometimes, however, fragments of the aggregates described above were noticed. Associated with this tin, as won from the surface of the dolomite area described, is a certain amount of pyrites, which necessitates classifying into first and second grade quality when cleaning up. A little galena was noticeable as well. These sulphides are undoubtedly derived, largely at any rate, from the dolomite. The tin sluiced from the granite bottom should be practically free from these impurities.

Perfect crystals of pyrite up to $\frac{1}{2}$ -inch in size, showing faces of the cube, or the cube combined with the octahedron, are frequently picked out of the sluice-boxes when cleaning up. These, too, were doubtless derived from the dolomite. Considering the granitic area from which the tin is derived, it is not surprising that pieces of topaz, garnets, zircons, and sometimes small sapphires are found also. Occasionally coarse irregular pieces of native bismuth are noticed in the tin concentrate, derived from some lode not yet located.

Small quantities of gold, generally in very waterworn fragments, and of magnetite in octahedral crystals also find their way into the sluice-boxes.

A good deal of a heavy bright-yellow sand with a resinous lustre is noticeable, which proves to be monazite, a phosphate of the rare earths (cerium, lanthanum, and didymium, sometimes with thorium). This heavy sand was noticed by Mr. Montgomery, who suggested the presence of monazite. Mr. Waller⁽⁸¹⁾ also recorded its presence, stating, "This is the first locality in Tasmania, so far as I am aware, that this mineral has been found in its mother rock. Up to the present it has been found only in alluvial. It occurs only in small quantities, and can never be a serious impurity in the tin ore."

W. F. Petterd⁽⁸²⁾ also notes its occurrence: "In the alluvial tin-wash of the Stanley River a heavy sand occurs, which is left in the dish by the ordinary process of prospecting. It is very fine, pale-yellow in colour, and semi to quite transparent. Under the microscope it is found to be subcrystalline, and much water-worn. This is monazite."

This mineral has been found in many localities in Tasmania, and as Petterd⁽⁸³⁾ remarks, "it may be said to occur in almost all the alluvial tin workings, as well as in the vicinity of many of the acid eruptive rocks." At no Tasmanian locality is it of commercial importance. Where quantities are available, the percentage of thorium oxide has been found to be too low to pay for extraction. On the other hand, it is not likely to be detrimental in this district as an impurity in the tin concentrate, as the quantity present is not considerable. It was not observed *in situ* by the writer, though search was made for it, but it seems to occur disseminated through the granite, for it

⁽⁸¹⁾ *Op. cit.*, p. 2.

⁽⁸²⁾ Catalogue of the Minerals of Tasmania, by W. F. Petterd, 1910, p. 121.

⁽⁸³⁾ *Op. cit.*, p. 122.

was noted in many small creeks often of short length heading in and flowing through granite only.

What is the source of the alluvial tin found in the flats, and what its mode of concentration in the flats where it is now being worked? It has been shown that the nuggets and specimen pieces have been derived from lodes. These occur partly within the granite borders, partly in the surrounding sedimentary rocks intruded by the granite. Portion of the finer tin oxide also must be derived from the same source, part by the grinding and pounding action of the boulders, after the coarser pieces have been set free from the parent lodes. But it is very probable that a large amount of the finer crystals of cassiterite has been derived from the granite itself. Although occurring widely disseminated through the mass, and in quantities far from payable, weathering agencies have done their part in disintegrating the rockmass, while the various streams have assisted by mechanical action in breaking up the softened granite, and have done the sluicing, carrying the lighter material gradually to the ocean, concentrating the heavier minerals when suitable conditions offered for their lodgment. And so the rich patches of alluvial tin found in places to-day represent the natural concentrate from enormous quantities of denuded rock. Under certain conditions material collected and concentrated during one long denudation period may be scattered, only to be rearranged and reconcentrated in new positions. This has certainly occurred with the alluvial deposits under review. The remains of terraces of alluvial material at different levels along the banks of the Pieman, Wilson, and Stanley Rivers have been described, and the explanation offered that these terraces represent different flood-plains. The river has cut its way deeper and deeper into the land surface, until the grade of its bed has become too flat to allow of the detrital matter being carried to the sea; consequently, it has been deposited. A subsequent uplift of the land-surface has rejuvenated the rivers, which immediately commence to cut through and redistribute the deposits already formed. As this action continues, the river-bed is gradually deepened once more, and remnants of former flood-plains are left high on the banks.

The concentration of the tin ore in the Stanley Reward alluvial flats has been greatly assisted by the presence of the hard bar of slate described elsewhere in this report.⁽⁸⁴⁾ This has acted in the bed of the river, exactly as a riffle

(84) *Vide* page 130.

acts in the bottom of a sluice-box; the lighter material is carried over, while the heavier concentrate tends to remain behind the obstruction. Some cassiterite must necessarily have been carried over the bar, but the bulk has been held back. On examination of this bar of altered slate one is not surprised that it has resisted so well the attempts made by the river to wear it down at the same rate as it has worn down the dolomite and some of the other rocks which, although hard, may not on account of texture or mineralogical composition be able to withstand chemical change. The slate is extremely fine in texture, and excessively hard. A microscopical examination of a thin section shows it to be a contact-metamorphic spotted slate. The carbonaceous material is collected in knots; the groundmass is even and very fine-grained, with a few scattered quartz grains. The upper surface of the rock, as exposed in the river-bed, is worn very smooth, and appears little altered even immediately below the surface.

Had this bar not been present, there can be little doubt but that the alluvial flats developed would not have been so extensive. While cutting down of the grade of the river-bed was hindered so considerably at this point, the water-courses were still delivering their contributions to the Stanley River, both of cassiterite and of rock-debris, and much of this was deposited, since the grade was too flat to allow of its transportation further down stream. Thus, to this hard rocky bar, regarded by those anxious to work the deposits as a great hindrance, the economic value of the deposits is largely due.

One point is worthy of note here, to dispel a difficulty which has existed in the minds of some of the prospectors on the field, the fact having been mentioned to the writer on several occasions by different men on the field. It is said that in surveying for a projected tail-race to cut through this bar, it was found that the level of the bar in the river-bed was about 30 feet *higher* than the bottom of the wash in the flats some chains up the stream. This being accepted, it was assumed that the river which deposited the alluvial must have had another outlet, as it could not have flowed from a lower to a higher point. I am given to understand that a good deal of time has been spent searching for the true course of the old river, and that the assumption was finally made that the present Four-mile Creek⁽⁸⁵⁾ must represent the old river valley.

(85) *Vide* Plate II.

The feasibility of this argument from the topographical point of view has been mentioned elsewhere in this report.⁽⁸⁶⁾

That the idea is quite untenable is proved by field evidence. There is no granitic wash of any description in the Four-mile Creek, nor has tin oxide been found in its bed. Furthermore, remnants of river terraces with granitic and quartz tourmaline wash occur lower down on the banks of the Stanley, at a height of about 80 feet above present river-level, showing that its course has been approximately the same as that followed at the present time.

The case in point is an illustration of the fact that an imperfect understanding of the nature of the clay pug in the Stanley Reward workings has led to a good deal of searching for what does not exist. The difference in level mentioned between the rocky bar and the lower limit of the clay pug probably does exist, and it may well be greater than 30 feet, but this clay pug is not really alluvial wash at all (though a little wash does occur in the upper portion). It has been pointed out in another place⁽⁸⁷⁾ that this pug represents the thoroughly decomposed surface of the dolomite. Hence the fact that the weathering has continued to such a depth as indicated with reference to the river-bed is of no significance whatever in determining the true level of the river-bed.

While much cassiterite has been accumulated and deposited by the Stanley River itself, the various creeks flowing into the river have also contributed their share. When the gradient of the river-bed has become very flat, and alluvial material has been deposited instead of being carried on seawards, the creeks must necessarily have been affected also. The silting of the main river-bed has meant that the detrital material brought down by the creeks has gradually accumulated, firstly towards the confluence of the tributary with the main stream. But degradational forces have been active all the time, removing material both from the sides and bottoms of the valleys, both widening them and reducing the gradient, so that in certain cases the alluvial deposits have extended further and further up-stream. This is particularly evident in the case of Livingstone Creek and of Castle's Creek. In some cases the degradation of the creek-beds has not reached a sufficiently advanced stage to allow of the formation of allu-

⁽⁸⁶⁾ *Vide* page 5.

⁽⁸⁷⁾ *Vide* page 132.

vial deposits of any extent. Where the grade is steep the scour is usually sufficient to remove the alluvial deposits as fast as they form, although under specially favourable circumstances deposits of limited extent may form. So in Minor's and Rocky Creeks, for example, both steeply graded, some alluvial tin has been won, but the deposits have been small. New's Creek has proved rather more favourable; in many cases the gradient is very flat for some chains in length, and some patches of highly payable alluvial have been worked.

All the way along the Stanley River, above the Stanley Reward sections, alluvial deposits occur at intervals. Some work was done on some of the flats on the Upper Stanley, where the tin ore was found to be similar in mode of occurrence to that lower down, and its mode of origin is similar. The inaccessible nature of the country here has prevented any great amount of work being done.

In some cases the alluvial tin won is of such a nature that one is forced to the conclusion that the lode from which it has been derived is very close at hand. For instance, the detrital ore won by Messrs. Conroy and Roberts on Section 4771m, on a branch of New's Creek, has been derived from the outcrop of the Mt. Lindsay lode. Again, on the boundary dividing Sections 5720m and 5721m, and almost at its intersection with the northern boundary, a small patch of rich alluvial tin was won, and practically no work done in prospecting for the source of the tin. However, from the angular form of the fragments of massive tin oxide found, and the limited area over which it occurs, it has undoubtedly been derived from some vein close at hand. A close study of fragments of tin stone collected shows a considerable variation in the ore. Many of the nuggets are of masses of granular cassiterite, with no apparent gangue. Others, again, are granitic, the quartz and felspar being entirely replaced by cassiterite, accompanied sometimes by a little green tourmaline. Many of the specimen pieces are undoubtedly impregnations of country-rock, altered slates, and sandstones carrying irregular seams and granular masses of black or dark brown cassiterite. More definite evidence still of the mode of origin of the deposit was afforded by the discovery of two fragments actually showing the contact of granite and slate, both being impregnated with tin oxide.

There is no doubt, in the writer's opinion, of the origin of this patch of rich specimen ore. It has been derived from a vein or veins at the contact of granite and slate. About half a ton of tin oxide was found in a small patch of alluvial a few yards in diameter, and practically all was sharply angular. As the granite-slate contact is exposed here, a minimum of prospecting would probably expose the ore-body within a few yards of the spot where the tin ore was found.

If prospecting is carried on in the district there can be little doubt but that other secondary deposits of tin ore of similar origin to those described will be found, some of which will pay small working parties.

B.—GOLD AND OSMIRIDIUM.

(1)—*Gold*.

Gold is sporadically distributed throughout the district, but nowhere, so far as is known at the present time, in payable quantities.

Reference is made elsewhere to the occurrence of a little waterworn gold in the alluvial deposits worked for tin at the Stanley Reward. It is impossible to say whether this is derived from the granite itself or from the contact zone, but the latter seems the more probable.

In the Wilson River, too, a little gold has been won from time to time, but the quantity is small.

I was informed by Mr. J. O'Meara, a pioneer West Coast prospector, that payable gold exists in some of the creeks flowing into the Wilson River from the east. This area is occupied by Silurian sandstone, slate, and limestone, and it is quite likely that gold-bearing quartz reefs may occur.

In the western area of the district, on the head of the Meredith River (a tributary of the Pieman), some gold sections were taken up over 20 years ago, but no records are available of any gold being won, although it is not at all unlikely that the precious metal may occur.

(2)—*Osmiridium*.

Although at the time of the writer's field examination only two men were engaged in winning osmiridium in the district, attention has since been rightly drawn to its possibilities, and a considerable number have been attracted,

the exceedingly high price offered for the metal (about two and a half times the value of gold at the time of writing) inducing many to "try their luck."

The osmiridium is confined to the eastern portion of the area mapped, between the Wilson and Huskisson Rivers, where there is a long and comparatively narrow belt of basic rocks (gabbro, pyroxenite, and serpentine).

At the time of writing a report on osmiridium is being prepared by the Government Geologist, to be published as Bulletin No. 17 of the Geological Survey of Tasmania; hence the occurrence only will be remarked on here.

Osmiridium has not been discovered *in situ* in the district up to the present. It occurs in shallow alluvial deposits in creeks either entirely within the serpentine area or in the adjoining sedimentaries near the contact. Beyond any doubt it is derived from the serpentine.

It is known to occur in the Wilson River. Here it is either derived from the serpentine cut through by the river itself, or that drained by some of the tributary creeks.

Cutting through Section 5554M, 80 acres, chartered in the name of the Rosebery Prospecting Company, No Liability, in the vicinity of the Mt. Merton Mine, is a small creek known locally as Christmas Creek. This creek heads in the serpentine belt, flows in a general north-easterly direction, then bends round and flows north-west, eventually entering the Wilson River. In this creek, about $\frac{1}{4}$ -mile from the Mt. Merton Mine and the contact of the serpentine with the Silurian sedimentaries, osmiridium was being won at the time of the writer's visit. The depth of alluvial was but a few inches, and the method of working was to pan off in the ordinary prospecting dish. Not satisfied with treating the small amount of alluvial material present, care was taken to pick up and treat the soft sedimentaries forming the creek-bed to a depth of 6 to 12 inches. It was found by experience that much of the metal won was obtained from this bed-rock. Slate bands were regarded with especial favour, and the explanation is not far to seek. In this locality the strike of the slate is about at right angles to the course of the creek. The sharp upturned edges form excellent natural riffles, the heavy metal not only lodging behind these obstructions, but working its way well down into the crevices, for the slate is very soft, rather approaching a shale than a true slate.

The osmiridium obtained varies somewhat in coarseness of grain. Pieces up to $1\frac{1}{2}$ and 2 dwt. are said to have been

obtained from this creek. The average grain-size of the samples washed in my presence was medium rather than fine. An average size might be regarded as about 1 millimetre. A little fine metal was always present. The grains were generally decidedly angular, frequently showing signs of crystal faces, and but seldom rounded. The larger grains appeared to be aggregates of crystals. Associated with the osmiridium was a little fine cassiterite (derived from the stanniferous formation at the Mt. Merton Mine), also some "toad's eye" tin, and a good deal of chromite and magnetite, the two latter minerals and the osmiridium being derived from the serpentine.

It is quite unlikely that any defined lode-formation exists, but most probably the osmiridium has been scattered through the basic rock in disseminated grains, having crystallised out from the cooling rock magma as an ordinary rock-constituent. As weathering has proceeded and denudation has gradually worn down the rock-mass, the osmiridium has been naturally concentrated, while the disintegrated rock-material has been gradually removed by the streams. The osmiridium has been concentrated for two main reasons: (a) its wonderfully refractory nature and extreme resistance to the attacks of chemical reagents; (b) its extreme weight.

The nature of the rocks forming the belt from which the osmiridium has been derived has been described in another part of this report.⁽⁸⁸⁾

The approximate distribution of the basic rocks will be seen on reference to the accompanying map of the district.⁽⁸⁹⁾

It was in this district that the largest single piece of osmiridium ever discovered in the world, so far as is known, was found by Mr. James Sweeney, one of the two men referred to above, on April 20, 1913. The weight of this piece is said to be 2 ounces.

The district deserves more thorough prospecting than it has hitherto received, for almost certainly there remain in "nature's sluice-boxes" many rich pockets of this highly-treasured metal. Creeks, not only in the serpentine itself, but in the vicinity of the contact, may reasonably be expected to repay the prospector, while tin and gold may also be discovered in the contact-rocks.

⁽⁸⁸⁾ *Vide* pages 18 to 24.

⁽⁸⁹⁾ Plate II.

C.—IRON ORES.

The secondary iron ores of the Stanley River district are of no importance commercially, but brief reference may be made to one or two occurrences, as in one case in particular a failure to understand the nature of the deposits has caused an unnecessary waste of money and energy in prospecting.

In the serpentine area, between the Wilson and Huskisson Rivers, there are on the surface fragments of iron ore whose mode of origin does not appear to be understood yet, in spite of warnings given in the past by officers of the Geological Survey,⁽⁹⁰⁾ that such occurrences are not likely to be of value. These fragments seem particularly abundant in certain localities. For instance, in the serpentine country near Mt. Merton, on one ridge they were covering the whole surface, and several "pot-holes" were noticed, put in to test the occurrence. The deposit was seen to be purely superficial, with serpentine beneath. The masses consist essentially of limonite, with sometimes included magnetite. Between the Harman and Wilson Rivers a similar occurrence was noticed, but here in some places the limonite was seen to be encrusting surface-pebbles. One specimen shows a rounded quartz-tourmaline boulder, almost entirely included in limonite. The limonite and magnetite are derived from the serpentine. As the latter weathers the iron compounds are set free, and these residual crusts are formed. The magnetite set free from the serpentine has been mechanically included (exactly as were the pebbles noted above) in limonite deposited from solution.

These deposits or surface-crusts are not at all likely to prove of any economic value.

In the same district chromite is present in the various creeks heading from the serpentine country, and in the Wilson and Pieman Rivers, and the alluvial on their banks; but, as Mr. Ward has pointed out for the North Dundas district, the chromite is too small in amount to be of commercial importance.

(8)—SUMMARY OF THE GENESIS OF THE ORE-DEPOSITS.

In dealing with the general geology of the district, we have already seen⁽⁹¹⁾ how the present geological structure of the district has been brought about. We have seen how,

⁽⁹⁰⁾ For instance, see Geol. Surv. Bull. 6, p. 78.

⁽⁹¹⁾ *Vide* Chapter IV.

at the close of the Silurian era, there existed on the field three distinct sedimentary formations, and that already there had been one period of igneous activity, although unaccompanied by ore-deposition.

Such was the condition of the rock-formations of the district when, in Devonian time, a huge mass of igneous rock-material in the molten state (*i.e.*, a magma) was introduced. This took place deep under the surface-crust. As this great mass gradually cooled, changes were brought about in the originally homogeneous mass by the process known as differentiation. The more basic constituents tended to segregate towards the margin of the mass, and eventually this mass of partially differentiated material was forced into the crustal portion along a plane of weakness. This material did not reach the surface, but rose to different heights at particular points. With this mass the osmiridium of the district was introduced. As cooling took place there appears to have been some further differentiation before the material finally consolidated, forming the belt of basic rocks previously described. This intrusion must have weakened the crust and caused fissures at different points. It was probably into some of these that, at a slightly later period, small portions of the further modified magma were forced at isolated points, forming the diorites of the district.

A little later the still more acid portion of the great mass was forced upwards into the crustal region, probably along some zone previously weakened by diastrophic processes. There must still have been a considerable thickness of sedimentary rocks overlying the mass, which formed a huge dome of irregular shape. The sedimentary rocks were not only tilted and crushed by the enormous pressure, but profoundly altered. The heat given out by this great igneous mass, especially when assisted by gases and solutions given off in the latter stages of consolidation, played a very active part in this alteration.

The molten mass itself was still subject to differentiation; as it cooled it varied from time to time in composition at particular points. One portion became rich in iron, with other substances collected from the molten mass by the agency of some chemically active substance, and this material forced upwards through some of the fissures previously developed formed the contact-metamorphic deposits. This was before the consolidation of the igneous rock. As the outer crust solidified, still more acid types were being evolved in the still highly heated central por-

tion of the mass. Contraction of this crust on cooling caused fissures to develop, and on this release of pressure some of the molten material was forced upwards, forming the various granite-porphry dykes. These sometimes penetrated the overlying sedimentary rocks. But differentiation was still continuing, and the still molten portion becoming extremely acid. Some of this material intruded into the overlying burden of rocks, both igneous and sedimentary, formed the abundant quartz-tourmaline veins and dykes of the district, sometimes cassiterite being present as well. Vapours and solutions were very active at this period, and, finding their way upwards, resulted in the formation of some of the tin-bearing veins, for minerals which could be retained in solution at the high temperatures and pressures at which they left the magma were precipitated in the cooler upper zones. With regard to the vein-forming solutions given off at this time, Mr. Ward's remarks on the North Dundas tin ore deposits apply with equal force to the types developed in the Stanley River district. He says⁽⁹²⁾: "The pressure must have been exceedingly great, even where ore-deposition took place, and the solutions probably forced apart the fissure-walls until free crystallisation was possible. The internal evidence of the ore-bodies affords proof of this free crystallisation, and the pressure conditions may be deduced. For it is now known that certain lode-forming minerals are characteristic of certain zones of depth, or types of veins."

On the final solidification of the granite a certain amount of cassiterite was included throughout the mass of the rock. This was destined to become important economically, owing to natural methods of concentration in the secondary deposits.

At the close of this period of igneous activity the introduction of ore-material into the district ceased. It remained now for the secondary ore-deposits to be formed. It has already been pointed out that the effect of the long-continued period of gradation impressed on the district since the Devonian time has been to wear down the land-surface, to lessen the grade of the rivers, and gradually cause a deposition of detrital matter which they were unable to carry off. The degradational processes, in removing the thick covering of sedimentary rocks which had been present at the time of ore-deposition, had done good ser-

(92) L. K. Ward: *The Tinfield of North Dundas: Geol. Surv. Tas. Bull. No. 6*, page 79.

vice in exposing the various lodes which had been formed deep beneath the surface. The disintegration of the lodes under continued action of these processes of denudation provided much of the mineral contained in the secondary deposits. In addition, much has probably been derived from the main granite mass, for not only has it been exposed, but it has been deeply dissected, and while the lighter material has been carried off by the streams, much of the valuable cassiterite has been concentrated. In the accumulation of rock-material the minerals of economic value have been concentrated. Thus both tin oxide and osmiridium have been accumulated (in different parts of the district) in payable quantities owing to the action of the processes which have removed so much of the old land surface.

In the case of the tin deposits the uplifts of the district have caused a redistribution and reconcentration of the first deposits of secondary ore formed.

VI.—THE HISTORY OF MINING ON THE FIELD.

The first discovery of tin on the field appears to have been made about 1893, by Messrs. Albury, Mitchell, and Upchurch. Prospecting up the Stanley River they got a little tin, and finally obtained fair prospects of alluvial tin on some flats of small extent south-east of Mt. Livingstone. Further prospecting revealed sections of wash consisting essentially of quartz-tourmaline on the banks of the river, very close to the granite-contact. The flats here were found to be extensive, and prospecting along the river-banks showed that the wash exposed carried rich tin. Two reward claims of 80 acres each were immediately applied for, and these were granted—one in the names of Albury and Mitchell, and the other in the name of Upchurch.

A syndicate was afterwards formed in Zeehan, and work was commenced to sluice the alluvial deposits adjacent to the Stanley River. I am informed that a fair quantity of tin oxide was won, but the ground became flooded whenever heavy rain was experienced. This disadvantage, combined with the heavy costs of packing, and other difficulties inseparable from working in an isolated locality, without any regular means of communication, and the low price of tin at the time, caused work to be discontinued. Meantime prospecting was going on in the neighbourhood of the Stanley Reward claims, with the result that other discoveries of alluvial and lode tin were made. Along a creek entering the Stanley River, about a quarter of a mile above the flats already being exploited, and flowing from Parson's Hood, prospecting was carried on by New and party. The creek is now known as New's Creek. Patches of alluvial tin were located, but there was no great extent of wash. Several quartz-tourmaline lodes were located, and it was reported that some of these carried very rich tinstone.

About the same time further discoveries of alluvial tin were made along the Upper Stanley, some 4 or 5 miles above the reward sections. Had they been more favourably situated, these discoveries would probably have attracted more attention, but conditions were unfavourable to profitable working. The country is very rough and heavily timbered, and it was found impossible to get supplies on to the ground.

Minor's Creek, flowing from the granite of Parson's Hood into the Stanley, was also found to carry small patches of payable tin oxide. Work here was hampered by the number of large boulders of granite and the thick undergrowth.

Work seems to have been carried on for some time intermittently, but owing chiefly to the excessive packing costs over such a long distance, work was practically suspended, and the field neglected for several years.

With an advance in the price of tin, attention was once more directed to the alluvial deposits along the Upper Stanley, and a party of prospectors cut a rough track from the Stanley Reward along the eastern side of the Stanley River. The difficulties which had to be overcome, however, militated against success, and operations did not prove profitable.

In 1902 Messrs. Castle, Davis, and party, after prospecting in various parts of the field, commenced sluicing in a creek now known as Castle's Creek. This creek, as will be seen by reference to the accompanying map of the district,⁽⁹³⁾ rises in the granite foothills of the Meredith Range, and flows into the Stanley River about a mile above the reward sections. The exact amount of tin won is not known, but the bed of the creek was sluiced for a few chains up from its junction with the river. The Stanley River Tin Syndicate was formed in Zeehan with the object of prospecting for the lodes from which this tin-stone had been shed, and several leases were applied for in the names of H. Castle, W. Castle, and A. D. Sligo. Several quartz-tourmaline outcrops were located, some of them carrying encouraging tin values, and a little prospecting work was done to open them up, this work being mainly confined to that known as "Castle's" lode.⁽⁹⁴⁾

In spite of results which were regarded as satisfactory, the cost of getting any milling plant on to the ground was found to be prohibitive, and the leases were eventually allowed to lapse.

About the same year Mr. H. Mackay formed a syndicate, and a number of leases were taken up on the western slopes of Parson's Hood, along Minor's Creek. The creek-bed was worked at several points, work being hampered by the thick scrub and huge granite boulders present. Here, again, quartz-tourmaline was found to be abundant,

⁽⁹³⁾ *Vide* Plate II.

⁽⁹⁴⁾ *Vide* page 64.

and it is said that several tin-bearing lodes were discovered on the leases, but under existing conditions it was considered inadvisable to continue work.

Further prospecting about the same period resulted in the discovery of several quartz-tourmaline dykes *in situ* in the granite on the summit of the North Parson's Hood spur. The Parson's Hood Syndicate was formed, and a fair amount of work carried out under the direction of Mr. Geo. Barker. This included trenching and shaft-sinking, and although values are said to have been located, these were not considered sufficiently encouraging, considering the inaccessible position, to warrant any further expenditure.

Some six or seven years ago Mr. H. Mackay secured an option of the sections charted in the name of R. W. Maskell (formerly known as the Reward Sections), and a fair amount of work was done in the way of boring and sinking trial-shafts to test the depth and value of the wash at various points on the flats adjacent to the Stanley River. The option was not completed, and for some time very little work was undertaken on the field.

About the year 1909 the Mt. Lindsay ore-body was discovered by the well-known West Coast prospector, Mr. T. Macdonald, and this again attracted attention to this neglected field. From that time forward work has been carried on at Mt. Lindsay.

Up to this time the regular route followed in travelling to and from the field was by the track direct to Zeehan, across the button-grass country. The Stanley River had to be crossed by a cage, and the Pieman likewise. Consequently packing was difficult and expensive. Recognising that something would have to be done to afford more certain and better means of access into the country north of the Pieman River, several of those interested in the Stanley River field approached the Government to construct a track from the Meredith siding on the Emu Bay Railway, and to erect a suspension bridge over the Pieman River capable of carrying pack-horses. This work was eventually agreed to, and carried out between four and five years ago. It is a matter for regret that more judgment was not used in the construction of the track, as a better grade could easily have been secured in many places; but even as it is, it has proved a great boon, prospectors and others being now able to have supplies and necessities packed from Renison Bell into country which had previously been extremely difficult and costly to penetrate.

Following on the construction of the bridge and track, negotiations were successfully entered into for the flotation of Maskell's (reward) sections in Melbourne, and subsequently the plant for hydraulic elevation was erected on the property, and work commenced.

The company ceased operations before long, and for some months the plant lay idle, and there was little activity on the field. Subsequently the plant and sections were let to tributers, who are still working.

In 1911 Mr. A. D. Merton discovered tin to the east of the Wilson River, and work was commenced here. This portion of the country, between the Wilson and Huskisson Rivers, was difficult of access, being reached by crossing the Pieman River by cage near the confluence of the Huskisson. Quite recently, however, a bridge has been constructed over the Wilson River about $\frac{1}{4}$ -mile above its junction with the Pieman, and a well-graded corded track constructed to connect with the Stanley River track at the Wilson River bridge. This work renders an important belt of country accessible, and one result has been renewed prospecting for tin, osmiridium, and gold.

Such, in brief, is the history of mining on the Stanley River Tinfield.

For much of the information contained in this chapter I am indebted to Mr. A. D. Sligo, of Zeehan, to whom I would tender thanks.

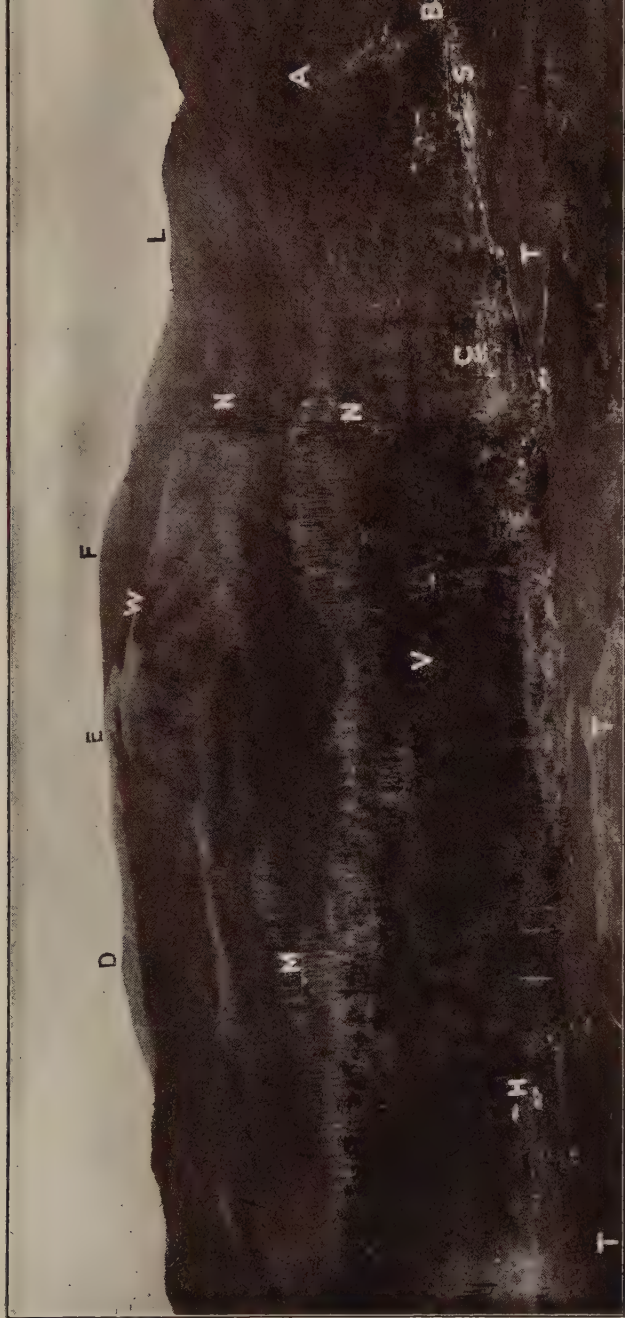
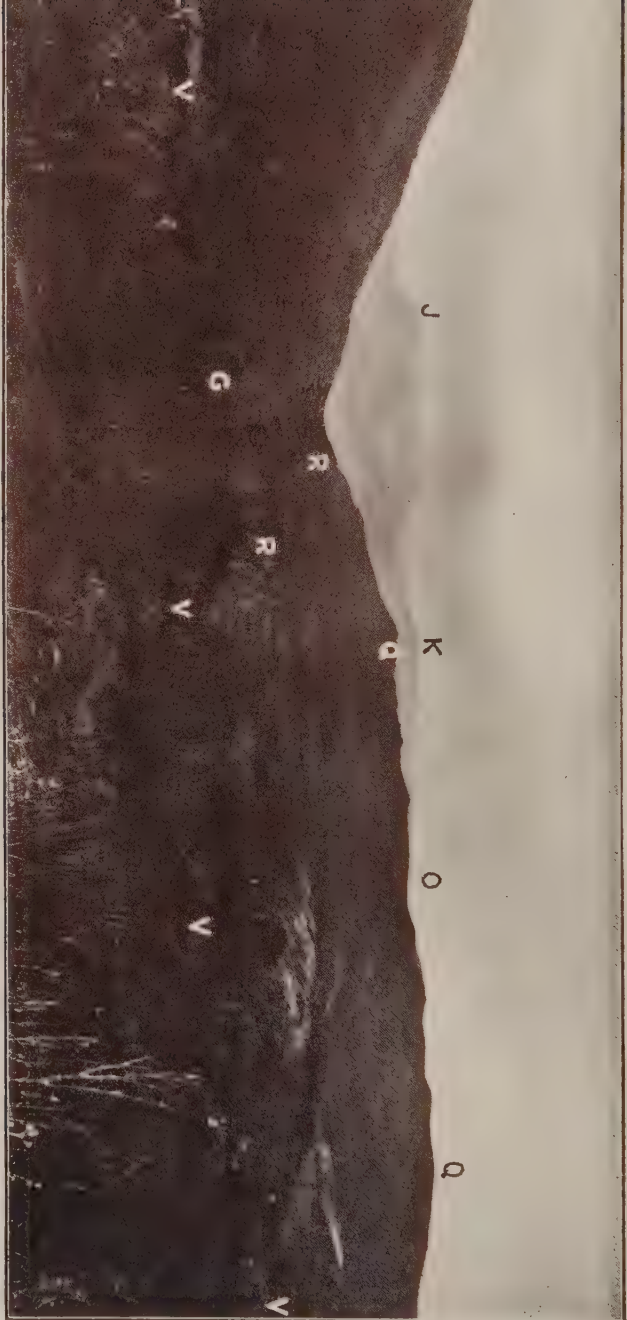


PHOTO. 5—PANORAMIC VIEW OF STANLEY R

WARD ALLUVIAL TIN MINE AND ENVIRONS.



[L. L. Waterhouse, Photo.]

VII.—THE MINING PROPERTIES.

(1)—THE STANLEY REWARD TIN MINING COMPANY, NO LIABILITY.

The property held by this company consists of 160 acres, comprised in two 80-acre sections, viz., 133M and 134M, charted in the name of R. W. Maskell. These sections were previously held as reward claims, and were charted as 1940-91M, Albury and Mitchell, and 1941-91M, Upchurch. These were the first sections taken up on the field. In addition to these sections the company has a water-right, 1055-M, R. W. Maskell, for 25 sluiceheads in the Stanley River.

The sections are in the valley between Mt. Livingstone and Parson's Hood, being south-east of the former and south-west of the latter.

The property is about 15 miles north-west of Renison Bell, with which it is connected by pack-track, generally corded, though with natural surface in lengths of several chains, at intervals throughout its length. The mile-peg marking 8 miles from the Pieman River suspension bridge is situated on Section 133M on the west bank of the river. The track is badly graded, and in consequence heavy packing charges place the company at a great disadvantage. An older track through open button-grass country nearly all the way connects direct with Zeehan, a distance of about 19 miles, but as both the Stanley and Pieman Rivers have to be crossed by cages this route is now seldom used.

Aneroid readings show the height of the Stanley Reward flat to be about 690 feet above sea-level on the river-bank at the track crossing.

The sections are situated on the Stanley River, at the junction with the river of New's Creek from Parson's Hood, and Livingstone and another creek from the Meredith Range; all these creeks are tin-bearing.

The area of the alluvial ground included in the two sections is about 50 acres. This does not include a small flat running about south-east, and crossing the eastern boundary of Section 134M, to which reference will be made later on.

The rock-types represented in the sections are varied. The northern portion of 133M is granite. This comprises the most southern extension of the Meredith Range *massif*. Occupying most of the southern portion of this section are the alluvial flats, and here no outcrops occur. The button-

grass cover perfectly conceals the wash beneath. The work done, however, indicates that the underlying rock here is white crystalline dolomite. The nature of this dolomite has previously been described.⁽⁹⁵⁾ At no point does the dolomite outcrop at the surface, hence its exact boundaries cannot be accurately determined. It is known to extend southwards into Section 134M, where it forms the bottom for a worked-out paddock.

The south-eastern portion of Section 133M and the north-eastern of 134M are occupied by members of the Dundas slate series of Pre-Silurian age, hardened and altered owing to their proximity to the granite intrusion.

In the south of Section 134M are white sandstones, quartzites, and slates, possibly of Pre-Cambrian age.

The Stanley River flows southwards through the centre of the northern section, bends south-west at the southern boundary, and then flows south again along the western boundary of the southern section, 134M. Crossing the river in this section is a hard bar of slate, with a strike of north 75° west, and apparently dipping north at about 85°. No surface outcrops are available for inspection on either bank, but the outcrop in the river-bed is about 3 chains in width. Reference has already been made to this slate bar.⁽⁹⁶⁾

In dealing with the property under consideration there are two distinct units to be discussed, which will be dealt with separately.

(a) The alluvial tin deposits along the Stanley River and Livingstone Creek.

(b) The stanniferous lode-formation near the western boundary of Section 133M.

(a) *The Stanley Reward Alluvial Tin Deposits.*—The majority of the tin-bearing alluvial is included in the northern section, 133M. At the present time the larger part of this is unworked. The main flat runs north-west and south-east, and is called the Livingstone Creek flat, from the main creek now cutting through it. This flat is mainly open button-grass, with thick scrub and timber on the borders, which has encroached in places on to the alluvial flats. This scrub has given some trouble in the working of the flats. Although by burning-off the surface has been rendered quite accessible, the roots have hampered sluicing operations, and when the company was work-

⁽⁹⁵⁾ *Vide* page 43.

⁽⁹⁶⁾ *Vide* page 114.

ing one or two men were kept employed, I am informed, in collecting these at the face and burning them.

The fall in the river here, and in the surface-level of the flats, is very slight indeed, and it was found necessary to elevate the wash.

The wash consists of rounded pebbles and boulders of quartz-tourmaline, quartz, aplite, granite-porphry, granite, porphyroid, hardened slates and sandstones, and schist. Sometimes so-called "nuggets" of tin oxide of several pounds weight are found in the wash, also specimen pieces of lode-tin, with cassiterite forming more or less perfect pseudomorphs after felspar, in a quartz-tourmaline gangue.

The source of these varied components is obvious, as all occur *in situ* in the immediately surrounding country. The schist has been transported mainly by the Livingstone Creek from Mt. Livingstone and its foothills, the porphyroid and altered sedimentaries by New's and other creeks from the south-western slopes of Parson's Hood, while the various granitic derivatives have come from the various portions of the Meredith Range, cut through by the Stanley River and its tributaries.

The quartz-tourmaline boulders are by far the most abundant, which is not surprising considering their superior hardness and the resistance offered by the constituent minerals to the attacks of weathering agencies. The boulders are usually well rounded.

Granite boulders are comparatively scarce. This fact, too, is easily explained by considering the nature of the component minerals, and their behaviour under the attacks of weathering agencies. The mica and felspar offer comparatively little resistance. As they decompose quartz is freed, and consequently is abundantly represented in the finer portions of the wash. The granite boulders set free in the course of weathering gradually find their way to the watercourses, where the softness engendered by the decay of the felspar and mica causes them to be readily disintegrated by the grinding and pounding action they are subjected to in the beds of the streams: so the action is partly chemical and partly mechanical. Where chemical action is resisted, and mechanical action becomes predominant, the effect is to grind the boulders and gradually round and polish them, rather than to disintegrate them.

In the wash large boulders are scarce, but those of medium size are very abundant, and the large quantity of shingle to be elevated has added largely to working costs in the past. Excess of water, which very frequently could ill be spared from the nozzles, was necessary to elevate

this material, and in consequence, until a portion of the surplus water was diverted from the sluice-boxes the loss of tin was excessive.

The true wash rests generally in the southern portion of the workings, where the bottom was exposed, on what is locally called "pug." It is referred to by Mr. Montgomery⁽⁹⁷⁾ as "a false bottom of pug containing chalcedony, mountain leather, and pyrites." The nature of this "pug" does not seem to have been understood. It consists of a stiff bluish-grey to greenish-black clay, generally very coherent, sometimes gritty. In its upper portion it contains some pebbles of quartz-tourmaline wash and fine quartz gravel. In places fragments of asbestos were noticed. Also what appeared at first sight to be abundant fragments of shells, but which proved to be flakes of silica, undoubtedly derived from the band of quartz described as being intrusive into the dolomite, or from other similar occurrences.

This pug is of very variable thickness, from a few inches to over 30 feet. The upper surface, on which the wash rests, is comparatively even, but the lower surface, bounded by the dolomite, is extremely irregular. The dolomite itself may rise in jagged peaks almost to the surface of the flat, and be covered by only a few inches of pug and button-grass and no wash, or troughs of more than 30 feet may occur, with no solid dolomite enclosed in the thick layer of pug which fills these troughs.

Scattered pyrite occurs through the pug, and sometimes large crystalline aggregates of pyrite, or of pyrite-galenablende. It is said that a little tin oxide is present throughout.

The writer is of opinion that this pug represents simply the thoroughly-weathered and decomposed portion of the dolomite. The evidence available points strongly to this as the mode of origin. The impurities in the dolomite, among which finely disseminated pyrite would play an important part, would probably account for the peculiar dark colour. Under long-continued water action it is not surprising to find that small amounts of the wash, and of cassiterite, have penetrated to a certain extent the upper portion of the pug. Should this theory be correct it is quite unlikely that it will pay to sluice this material (excepting the upper layer) for contained tin. The pug seems to be regarded on the field as an integral part of the wash.

(97) *Op. cit.*, p. xxxi.

It was noticeable that in the extreme north-western corner of the paddock worked on the western bank of the Stanley River the wash was resting on a granite bottom, but the pug was absent.

The extreme variation in the depth of the pug, as noted above, explains the fact that in the early prospecting stages, prospecting shafts indicated such a great variation in the depth of wash. Occasionally they would bottom on dolomite very near the surface, while sometimes they would happen at a point where there was a deep trough in the dolomite surface filled with pug: here "bottom" might not be reached even at 30 feet from the surface.

A full discussion of the occurrence of dolomite, with theories as to its mode of origin and age, will be found in another part of this report.⁽⁹⁸⁾

The probable occurrence of defined lodes rewarding prospecting operations has also been mentioned. Ore-bodies of considerable size sometimes occur in such rocks, and the presence of pyrite, blende, and galena in what would seem from indications to be an ore-body of some feet in width should be kept in mind in laying-out future prospecting operations.

Of the abundant masses of pyrites scattered through the pug in the worked paddock on the western bank of the Stanley River, samples were taken, and finally a representative sample of these pieces, which almost certainly came from a lode *in situ*, was sent away to be assayed for tin. The Government Analyst, Mr. W. F. Ward, reported that the sample contained no tin.

A sample of the pyrite-galena-blende masses, also almost certainly *in situ* in the dolomite, was also selected from various points. For this Mr. W. F. Ward reported—

Lead	30.6 per cent.
Zinc	21.7 per cent.
Silver	14 oz. 14 dwt. per ton.

Until something further has been done in the way of prospecting to prove the extent of this ore-body little can be added to what has already been said ⁽⁹⁹⁾ with regard to the future of this lode-formation.

As some of the intrusive granitic rocks in the dolomite carry tourmaline it was thought that possibly the magnetite bodies already described ⁽¹⁰⁰⁾ might carry tin. A

⁽⁹⁸⁾ *Vide* pages 43 to 51.

⁽⁹⁹⁾ *Vide* page 101.

⁽¹⁰⁰⁾ *Vide* page 45.

sample of this material was also submitted for assay to the Government Analyst, who reported that no tin was present.

The origin of the alluvial tin occurring in the Stanley River and adjacent flats has already been described.⁽¹⁰¹⁾

The first discovery of tin in payable quantities in the district was made on these sections, now held by the Stanley Reward Tin Mining Company. When this find became known prospecting extended in various directions from this centre, resulting in several other finds being made.

The Stanley River is very flat in this locality, and some of the earlier attempts to work the ground known to be carrying payable tin resulted in failure, or at least partial failure, on account of the grade being insufficient to allow of the tailings being carried off.

A race was brought up the flat on the east side of the river on Section 133M in the early days of the field, and a small paddock worked from it, which is said to have yielded good tin. As the race was not more than 8 or 9 feet in depth it does not seem that the full depth of wash was treated here. In all the earlier work done the same drawback had to be faced.

Prospecting shafts were sunk at various points on the flats for the purpose of testing the depth and value of the wash, but these were all full of water at the time of the writer's visit, and no record was available giving particulars of the results obtained. This is a matter for regret, as an officer of the Geological Survey is always hampered in his work if full information is not placed at his disposal. He must necessarily rely on the companies for unreserved information of past efforts, if his report is to be complete.

With regard to the early attempts to work the property, Mr. Waller⁽¹⁰²⁾ summarised as follows:—"More than one attempt has been made to work this flat in a small way, but so far without success. The ground is very flat, and there is no chance of getting in a race with sufficient fall to carry away the tailings. In one place a drainage race has been brought up through the flat, but this is not more than 8 feet deep, and only enables the upper layers of wash to be worked. A small paddock was taken out at the head of this race, and is said to have yielded 10 bags of tin.

⁽¹⁰¹⁾ *Vide* page 114.

⁽¹⁰²⁾ "Report on the Prospects of the Stanley River Tinfield," by G. A. Waller, 1904, p. 6.

Another attempt was made to divert the Stanley from its present course in order to work the present bed of the river, and with this object in view, a dam was thrown across the stream. This was, however, washed away at the first flood, and the attempt was abandoned. It is now quite evident that the ground cannot be worked successfully without elevating the tailings. It has been suggested that the bar might be shot away and a tail-race brought up from the south, but I am of opinion that this is impracticable. The Stanley is very flat for a long distance south of the bar, and I very much doubt if sufficient fall could be got to carry away the tailings. In any case the cost would be practically prohibitive. The most feasible method of working the ground appears to be to elevate the tailings hydraulically."

Mr. Montgomery had also suggested the bringing in of a high-level race, and using hydraulic elevators.

After the construction of a pack-track from Renison Bell, and of the Pieman River suspension-bridge, the Stanley Reward Tin Mining Company, No Liability, was successfully floated, and a commencement made to get treatment plant on to the property. It was now fully recognised that hydraulic elevators and a high-level race were necessary, and the construction work was put in hand. The company was at a tremendous disadvantage, the pack-track being badly graded, and the clay soil softened and cut up badly where cords had not been laid, becoming almost impassable in bad weather, with the constant traffic of sledges and pack-horses. These difficulties, with the distance from the railway (15 miles), made the transport of various sections of the plant not only very slow, but very expensive. In the meantime work was proceeding on the race, and timber-work being pushed forward on the property itself.

Eventually all sections of the work were completed, and sluicing operations commenced.

Water is brought from the Upper Stanley River by a race between 3 and 4 miles in length, constructed on the slopes of the Parson's Hood Mountain, New's Creek contributing to the water-supply *en route*. By a column of 18-inch iron pipes, about 3000 feet in length, the water is brought to the flat, giving a head of about 300 feet. On the flat the main column is split into two, each of 12 inches diameter, one supplying the nozzles, the other the hydraulic elevator. The plant includes two hydraulic

elevators, two nozzles, large and small sluice-box, with various column bends, connections, and other necessary fittings.

The 12-inch column supplying the jet elevators is split into two, one connected to a larger and the other to a smaller elevator. The larger, and main, elevator has a $3\frac{1}{2}$ -inch diameter jet, 9-inch throat, and 12-inch pipe. There is a subsidiary 3-inch nozzle, which may be substituted for the $3\frac{1}{2}$ -inch one if required. The smaller elevator has a 3-inch nozzle, 8-inch throat, and 10-inch pipe-column.

The 12-inch column supplying the nozzles was also split into two, one to each nozzle.

On the hill about 60 feet above the flat, and just below the track, the blacksmith's shop and power-house were erected. In the latter is a dynamo worked by a small Pelton wheel driven by a jet tapped from the main column; this supplied light to the property. Arc lamps suspended over the sluice-boxes and in the paddocks being worked enabled night-work to be carried on.

The general method of working was to break down the wash by nozzles. The loosened material was carried by a race to the sump with the aid of ground water from the button-grass flat, the water used in breaking down supplying the main transportation power. From the sump it was elevated to the sluice-boxes, where it was treated for tin contents. The height of lift from the sump to the boxes was about 40 feet in the position in which the plant was working at the time of the writer's examination.

The nature of the wash has already been described, and the pug on which it rests, and the opinion has been expressed that this pug is a decomposition product of the dolomite, which forms an extremely irregular bottom beneath it. The class of tin won, and its source, have also been discussed in another part of this report.⁽¹⁰³⁾

The work done on the property since the erection of the plant has been small. In Section 133M on the eastern side of the river, and just north of the southern boundary-line, the first paddock was worked out. This was found to be about a quarter of an acre in extent. The bottom is dolomite of very uneven surface, but covered with clay pug, on which the true wash rested. This paddock was full of water at the time of my inspection, and no information could be gathered as to the nature or depth of wash round its edges. The hopper heap showed that quartz-

(103) *Vide* page 111 *et. seq.*

tourmaline pebbles were largely in excess of all others, though other classes were represented. From answers to enquiries it seems that the true wash must have averaged about 4 feet in thickness here. No record was available of the amount of tin won from the area. Some difficulty was encountered here in working, on account of the number of true roots and stumps met with. I was informed that several men were constantly employed in collecting these from the face, and burning them off, to allow the jets free play and enable the loosened detritus to be washed to the sump.

Then the elevator plant was moved to a position on the western bank of the river, still in Section 133M, and a second paddock, about $1\frac{1}{2}$ acre in extent, worked from here. The plant was being moved from this position by the tributaries at the time of my visit. It is a matter for great regret that the company, after erecting the plant under such difficulties, was obliged to suspend operations so soon. At the time of the writer's visit the property was let on tribute, and five men were employed. The tin being won by this party affords ample proof of the high tin values carried by some at least of the wash, and shows that portion at least of the alluvial can be worked at a profit.

The depth of wash exposed round the edges of the paddock worked, and available for inspection, varied from almost nothing at points where the dolomite rose in jagged points to the roots of the button-grass, to about 8 feet. The average depth, as exposed, was about 4 feet, with about 3 feet of overburden. From what has been said it will be understood that this estimate does not include the pug which caps the dolomite, and which the writer does not regard as true wash.

With regard to extent of ground, with the few details available as to the result of past prospecting operations, the writer cannot express an opinion which can be regarded as final. It is only by systematically testing the ground, and recording the results in a manner which will enable their significance to be realised, that extent of ground likely to be payable can be determined, and future work planned. From the mode of origin of the deposits, however, a few general remarks only may be made. It is unlikely that since the first period of base-levelling, and consequently the first alluvial deposits of tin ore were formed, the Stanley River has deviated to any considerable extent from the course it follows at the present time. This is shown by remnants of river gravels at different heights along the

banks of the present river. Hence the best tin deposits may be expected in the neighbourhood of the present river-banks. It must be understood, however, that when a flood-plain was formed, the detrital material brought down by the river, including the tin, would be spread out for some chains on either side of the river-bed as it was at that particular period. This statement is made to try and correct an impression which seems to have gone abroad with regard to the nature and origin of the long flat which runs up in a north-westerly direction from the Reward workings for about a mile, and known as the Livingstone Creek Flat. It seems to be thought that in some way this represents a former bed of the Stanley River, and that for this reason good tin should be obtained here, as well as along the main stream. This flat is divided by a steep granite ridge on the north-east from Castle's Creek and the Stanley River, this ridge being a spur from the Meredith Range. The flat has been developed by the same processes which have formed the flood-plains of the Stanley River itself, but the detrital material has been derived from Mt. Livingstone and its foothills on the one side (where no proved tin deposits occur), and the granite spur referred to on the other. Consequently, from theoretical reasoning, while a certain amount of tin is almost certain to be present, as a derivative from the granite referred to, and possible unknown lodes in the schist country, the amount present is likely to be comparatively small, and the relative amount of detrital matter large. The depth of deposit, too, is not likely to be as great as that derived from a larger stream under similar conditions. Consequently the places where one would expect to find the best wash would be in the vicinity of the present workings, and especially extending northwards along the main river-banks, the deposit appearing wider in extent on the western than on the eastern side of the river. This portion is covered by heavy scrub at the present time. Southwards to the bar referred to in Section 134M good wash may be expected.

One great drawback in the past has been the irregular water-supply. This has been to a great extent responsible for higher working expenses than the company anticipated. The variation in the amount of water in the Stanley River is surprising; while a day's rain causes a decided fresh in the river, even four or five days without rain causes a shortage. Even in the middle of winter, when the water-supply should be assured, work has frequently to be curtailed, or even stopped, on account of insufficient water.

It has been explained that both the elevators and the nozzles draw from the main supply. When there is insufficient to supply both nozzle and elevator, then work must necessarily stop. Mention has been made of the fact that a 3-inch jet may be substituted for the $3\frac{1}{2}$ -inch one on the main elevator. When water was running short the substitution was made in order to save water, but, of course, at the expense of amount of wash treated. If a stoppage occurred it was necessary to find work for the employees, as suitable men were difficult to secure, so little of this class of work being done on the West Coast. Thus, with practically no reduction in working expenses, the output would be reduced to nil. At times, of course, some, or perhaps all, of the hands could be put to useful work, but frequently it was necessary to employ them on quite unnecessary work.

The nature of the wash has been described, and comment has been made on the excess of boulders of medium size. This fact, too, was found to add considerably to working expenses, as the material was too large to be transported down the race by the tail water, and consequently was removed from the face by manual labour and stacked in the previously worked-out portion of the pad-dock. The employment of men at work of this description must undoubtedly have added to treatment costs.

The attempt to work on such an extremely uneven bottom as the dolomite presented must have been another source of trouble. If the writer's assumption with regard to the clay pug be correct (although actual tin values contained in the pug are unknown to him, and must be determined), then it would probably have paid better to regard this as the true bottom, and work accordingly, without attempting to sluice all the pug. That the latter may carry a little tin is not unlikely, and is, in fact, probable, particularly in the upper layers; or possibly, if pyritic-cassiterite veins occur *in situ*, in the vicinity of these.

During his inspection the writer noticed on more than one occasion that material in the race leading from the face to the sump was being assisted by actual hand labour, suggesting at once that the grade of the race was too shallow. That this is probably true is accounted for by the very flat nature of the ground. In such a race, however, even if hand labour be not employed, excess water would be required to move the material, which would probably cause excessive loss of tin in the boxes.

To obviate this a certain amount of the water was diverted, which improved the efficiency of the sluice-boxes.

It must be borne in mind that where fine cassiterite is present (and it undoubtedly is in this instance), there must inevitably be a loss where such a crude method of concentration as the sluice-box is employed. This may, of course, be reduced to a minimum by attention to details, such as amount of water, slope of boxes, spacing of riffles, and proper attention while sluicing.

With regard to the future of the property, as an alluvial proposition (the lode is dealt with independently) much depends on details of working whether it becomes a success or otherwise. The little information available seriously handicaps the writer in attempting to forecast. It becomes distinctly a question for the mining engineer to settle, rather than the geologist. A few general remarks, however, by way of summary, may not be out of place.

Factors such as variable water-supply and inaccessibility must be contended with, and are always likely to cause trouble. By certain extensions and improvements in plant the quantity of material treated and percentage of tin won might be improved, and working costs reduced, but against this must be considered the area of tin-bearing ground remaining to be worked, and its value. This must be determined by careful sampling if such has not already been done. It may be found that the area of high-grade ground is not sufficient to warrant any extension or costly alteration in plant; but from what the writer has seen of tin won by tributers with the present plant he feels confident that there should be still some years of profitable work on the property for a small party, if values really come up to expectations. The extent of dolomite is apparently small. On a granite bottom the pyrites so abundant on the dolomite bottom is likely to be absent, and consequently the grade of the tin won will be improved. The nature of the wash is likely to be fairly constant, hence some of the difficulties indicated may still have to be faced, but mechanical devices are available for improving matters in handling material.

One point must be borne in mind by the company in planning future work. A property may yield handsome profits to a small working party, but it does not necessarily follow that the same results will be attained under company management. In the present case, careful and systematic sampling by a thoroughly competent mining engineer will give information of the utmost value as to the exact extent and true value of the tin-bearing ground. This information can be obtained in no other way, and

with it and the experience gained from past working, the future policy can be confidently planned.

(b) *The Stanley Reward Lode-formation*.—Towards the north-western corner of section 133M a little work has been done on a bold outcrop of haematite and limonite with some magnetite, which was found to be tin-bearing. It is situated almost on the western boundary of the section and on the eastern boundary of Section 3985M of 20 acres, charted in the names of D. W. Albury and W. F. Maskell, into which section the ore-body apparently extends. It appears to have a general north and south strike. The outcrop is but a few feet from the edge of the alluvial flat. Although some patches had been cleared, parts of the outcrop are covered by thick scrub, and are quite inaccessible.

Mr. Montgomery⁽¹⁰⁴⁾ refers to this occurrence thus: "Near the western boundary of 1940-91M there is a gossan formation on which some work has been done, and which seems to run very much along the contact of the granite and Silurian country. Some of this yields really excellent prospects of very ragged tin ore. This lode requires to be much more thoroughly tried, and according to the prospects obtained by me is well worth spending some money upon in doing so. It is mostly oxide of iron, and probably will turn to pyrites in depth. There is a large body of gossan."

Mr. Waller⁽¹⁰⁵⁾ also refers to this deposit. He quotes Mr. Montgomery's report, and goes on to say: "I think it is probably one of the contact deposits already referred to, and will turn to magnetite and pyrites in depth. The presence of tin in the gossan at the surface is encouraging, and warrants the formation receiving a fair trial."

In spite of these favourable opinions of the prospects of the ore-body, practically no work has been done, and little beyond surface outcrops were available for inspection. However, the writer was very favourably impressed with what he saw.

The lode seems to have been discovered from the detrital matter set free by weathering agencies. Tin was found on the edge of the flat, and this was traced up to the outcrop of the formation. Report states that when first discovered the outcrop was only about 2 inches in width, but rapidly widened. This does not seem quite in accord with the outcrops exposed in other spots, where the formation

⁽¹⁰⁴⁾ "Report on the Progress of the Mineral Fields in the Neighbourhood of Zeehan," by A. Montgomery (1895).

⁽¹⁰⁵⁾ "Report on the Prospects of the Stanley River Tinfield," by G. A. Waller (1904), p. 7.

appears to be between 30 and 40 feet wide in places. However, the whole was very thickly overgrown with scrub at this time, and as many parts were covered at the time of the writer's visit, he was satisfied that it was utterly impossible to see anything without clearing. At any rate, the portion of the lode outcropping at the point where the discovery was first made was evidently very narrow. This was very close to the western boundary of Section 133m. The deposit seems to have originally been worked by tributers; hence these workings are now known as the "tributers' workings." Some good tin was won from the alluvial at this point, and then a shaft was sunk for 9 feet on gossan, and a drive put into the hill for about 40 feet; then a rise connected with the surface, about 16 feet. From this drive the gossan was stoped right to the surface. Nothing was seen of these workings, all being filled in. Samples of the gossan were obtained from surface heaps, showing good tin oxide. The gossan is said to have been quite soft here, and good picking ground; width worked was about 8 feet. The formation here is apparently right at the edge of the intrusive granite, from which it is separated by about 2 feet of soft, white clay, which is said to have carried up to a bag of tin oxide per cubic yard. The writer was not able to verify this figure.

About 100 feet in a direction a little east of south from these workings are the "company's workings." Little more is to be seen here of the occurrence. A shaft now partly filled in is said to have been sunk to a depth of 22 feet; crosscuts were put in from this depth, 10 feet east and 10 feet west. It seems that the western cross-cut was in soft clay, the boundary of which was not met. This is said to carry 2 per cent. of tin. The eastern cross-cut was in hard gossan, apparently dipping east. The lode appears to be about 40 feet wide at this point.

Some surface work was done here, several tons being taken out by a small open-cut. The gossan and kaolin treated from here gave good returns. The formation appears to be dipping at a steep angle into the hill east. The western edge of the brown gossan is not exposed, but to the east is about 10 feet of soft, banded, white, thoroughly kaolinised material, the banded structure being distinctly shown by fine parallel threads of red and brownish iron oxide running continuously through it. Undoubtedly these fine red threads and bands represent thoroughly oxidised mineral, probably largely pyrite. Running through this material are small fissures filled with quartz, with fine seams of black tourmaline. This is a significant

fact. While this belt of iron-stained kaolin is said to carry fine cassiterite all through, none at all seems to have been found in the succeeding banded white clays on the east, here exposed for about 10 feet. The mineralisation which has so affected the other bands seems to be wanting here, although several intrusive tongues of granite-porphry carrying black tourmaline were noticed, the rock being now thoroughly decomposed, and so soft that it may readily be crumbled in the hand. Bands of white tremolite were noticed here also, said to have been tried several times, but found to carry no tin whatever. None was present in the sample obtained by the writer. The formation at this point has been worked for a width of 12 feet, length 20 feet, and to a depth of about 15 feet.

Some further work was done a little south of this. Although nothing could be seen here, I am informed that three shafts were sunk on the gossan, each to a depth of about 20 feet. In one instance a drive is said to have been put in for 20 feet in gossan. These workings are now quite filled in.

A piece of work not previously described is that on the western boundary of the section, at a point $1\frac{1}{2}$ chain south from the south-eastern corner peg of the 5-acre section, 4183-M, previously held by A. C. Gordon. Here it seems that a shaft was sunk to 20 feet, wholly within soft weathered granite, and a crosscut of a few feet driven to cut the gossan, which forms a bold outcrop at the surface. The outcrop here is mainly hematite and limonite, with a little magnetite, and decomposing pyrite showing in places. In several pieces broken off, tin oxide was noticed scattered through the gossan. It occurs both in fine disseminated crystals, and in aggregates of coarser crystals, forming ragged masses about a quarter of an inch in diameter.

Some trenching has been done just below this outcrop on the adjoining section to the west—3985M, 20 acres. This will be described later when referring to that section.⁽¹⁰⁶⁾

From the surface detrital matter, between this trench and the outcrop referred to above, two dishes were washed by Mr. Albury in my presence, with surprisingly good results. There is abundant fine, black cassiterite, and in addition many coarser ragged aggregates, as described above. The small amount of magnetite present in the concentrate was rather a surprise to the writer. One noticeable feature was the presence of large crystals, up to 1 inch

(¹⁰⁶) *Vide* page 189.

in length (or breadth), showing dominantly octahedral faces, and coated with iron oxide. These were mistaken on the field for magnetite, but prove to be crystals of decomposing pyrite. Some crystals show combinations of the octahedron and pyritohedron, others the octahedron and cube. These are evidently set free by weathering from the outcrop referred to.

A further reference to this ore-body and its probable mode of origin will be found in another part of this report.⁽¹⁰⁷⁾

With regard to the method of treatment, water was brought from a point on the Livingstone Creek⁽¹⁰⁸⁾ by a short race and light pipe-line about 27 chains in length. Practically no head was obtained, but the alluvial material was free and unconsolidated, and the tin was saved in sluice-boxes in the usual way, the tailings being conveyed to Livingstone Creek at a lower point. The stanniferous banded kaolin referred to was puddled, and then put through the boxes. The tin oxide from this material is said to have been very fine.

Mr. D. W. Albury informed the writer that as much as 7 cwt. of tin oxide to the cubic yard was obtained from the tributers' workings, and 3 cwt. to the yard from the company's workings; also that nearly 10 tons was won from the ore-body, and over 1 ton from the alluvial.

The formation appears to have been prospected at intervals over a length of about 400 feet, and prospects have been decidedly encouraging.

While it is a matter for regret that the ore-body could not be seen in more detail, so that its structure could be explained more clearly, and suggestions for future work offered, sufficient was seen to enable the writer to form a high opinion as to the possibilities of the ore-body.

It is of considerable size, and should the average quantity of the ore be right, as shown by systematic prospecting work, accompanied by careful sampling at various points, the quantity available is large. It must be borne in mind, however, that the tin values may not be constant, either as regards the width or length.

Some of the specimens obtained undoubtedly do carry high values in tin. It remains to be seen what these values will be when taken over average working widths. From information supplied, it would certainly appear that there is little to be feared on this score.

⁽¹⁰⁷⁾ *Vide* page 99.

⁽¹⁰⁸⁾ *Vide* Plate II.



PHOTO. 6.—Portion of Mt. Lindsay Mine.

[L. L. Waterhouse, *Photo*

It is unfortunate that the topography will not admit of exploitation by adits. When development work is commenced in earnest it will be necessary to sink a main shaft and open up the ore-body by levels and crosscuts at regular intervals.

If the company is satisfied with the results of samples taken at various points, and not only at one or two places where veins of rich tin ore may occur, the question of a treatment plant will necessarily have to be considered. Here transport difficulties unfortunately place the company at a great disadvantage. Although the construction of the Pieman River suspension-bridge has been of immense service to the district, it is still impossible by the only available means of transport (*i.e.*, pack-horses and sledges) to get any heavy pieces of machinery on to the ground, and even for lighter pieces which could be got on to the ground exceedingly heavy packing charges have to be paid. This but emphasises the necessity for carefully prospecting before erecting a treatment plant. One other point must be kept in mind: the ore known to exist at the present time is oxidised; its treatment will offer no great difficulties. But, as has already been pointed out⁽¹⁰⁹⁾, there are strong reasons for believing that the character will change at no great depth, and that sulphides will take the place of the limonite and some of the haematite, though magnetite will probably prove to be a primary mineral. The company may then have to face the problem of the treatment of an essentially sulphidic tin ore, instead of an oxidised one. For this reason a small plant is to be recommended rather than an expensive one, which might prove quite unsuitable when the primary ore was reached.

Indications are sufficiently encouraging to warrant active prospecting and development work on the ore-body, with a reasonable prospect of the venture proving a highly profitable one.

(2) THE MOUNT LINDSAY MINING COMPANY, NO LIABILITY.

This company holds a consolidated lease, 5876m, of 140 acres, charted as above; also water-rights, 1167-w, for four sluiceheads on Tulloch Creek, and 1211-w, for two sluiceheads on South-East Creek; and an easement for sludge-channel for 56 chains—all charted in the name of R. F. Irvine.

(¹⁰⁹) *Vide* page 100.

The lease is situated on the southern slopes of the Parson's Hood Mountain, and is distant about 15 miles north-west of Renison Bell (the nearest railway-station on the Emu Bay Line), with which it is connected by a corded pack-track. The Mt. Lindsay track is really an offshoot from the older track to the Stanley Reward sections. At 5 miles 70 chains from the Pieman River suspension bridge the Mt. Lindsay track turns off to the north, rising from 870 feet above sea-level at the junction of the tracks, to 1485 feet above sea-level at the manager's office at the mine, a distance of about $1\frac{1}{2}$ mile.

The mine is about 2 miles east of the Stanley Reward property, and over 1100 feet above it at its highest point.

As will be seen by reference to the plan accompanying this report,⁽¹¹⁰⁾ there are two approximately parallel spurs trending southwards from Parson's Hood, South-east spur, 1580 feet, and Mt. Lindsay spur, 1820 feet, above sea-level, with Tulloch Creek in the valley between them flowing southwards, 1450 feet in elevation, where it cuts through the ore-body. The Mt. Lindsay spur forms the divide between the Wilson and Stanley Rivers, both tributaries of the Pieman River. Tulloch Creek enters Four-mile Creek, a tributary of the Wilson.⁽¹¹¹⁾ The accompanying plan shows that the outcrop of the ore-body has been traced down the western slope of the South-east spur, across Tulloch Creek, up the eastern slope of Mt. Lindsay spur, across this spur, and for some distance down the western slope. The present lease includes a considerable length along the line of lode, totalling about 55 chains as already prospected. The formation has a general strike of about north 80° west, and dip south at 75° to 85° .

The extreme north-western corner of the section is occupied by an outcrop of granite of Devonian age, which forms part of the Meredith Range *massif*. In two localities intrusive dykes of granite-porphyry were noted, the remainder of the lease being occupied by members of the Dundas slate series, of Pre-Silurian age, which form the country-rock of the ore-body. The Pre-Silurian rocks are all metamorphosed, belonging to the contact-metamorphic aureole of the granite, but they are dominantly of sedimentary origin, slates being the main type represented, with subordinate bands of sandstone, and probably of tuffs. Igneous porphyroids may also occur, but were not noticed *in situ*, though loose fragments were found through

⁽¹¹⁰⁾ Plate VI.

⁽¹¹¹⁾ *Vide* Plate II.

the district. The old sedimentaries are now scarcely recognisable as such, being converted to what appear to be hard, blue cherts and quartzites. Microscopically these rocks show the presence of quartz, albite, actinolite, biotite, andalusite, and sillimanite. Some extremely interesting rocks showing these typically contact-metamorphic minerals were collected from a small side-cutting made for the track, near the Tulloch Creek crossing.

The country-rock weathers to a stiff yellow or brown clay in places, but generally remains fresh right to the surface.

The spurs are heavily timbered, sometimes with very thick undergrowth as well as forest timber, rendering prospecting difficult.

The ore-body was discovered by that veteran West Coast prospector, Mr. T. MacDonald, by prospecting up the bed of Tulloch Creek. The outcrop of the ore-body was discovered in the bed of the creek. It was originally taken up as a nickel reward section of 80 acres, another 80 acres being afterwards added.

Eventually, instead of the second 80-acre section, three sections of 20 acres each were secured, and finally these three amalgamated with the original 80-acre section, making up the present consolidated lease, 5876-M, of 140 acres.

Shortly after its discovery the ore-body was stripped on the west side of the creek near the present Tulloch adit,⁽¹¹²⁾ and the pyritic formation exposed for a width of about 100 feet. A bulk sample across 90 feet at this point is said to have assayed 6.5 dwts. gold, 7 to 8 per cent. antimony, and 1.5 per cent. nickel.

Mr. Cameron took charge and trenched across the formation about $1\frac{1}{2}$ chain south-west from the previous stripping (No. 1 trench), driving a short adit about 6 feet north-east into the dense pyritic ore.

I am informed that when Mr. A. E. O'Brien took charge of operations in 1910, the only work done on the ore-body consisted of these two trenches and a few isolated prospecting holes. When it is remembered that at this time dense scrub was dominant, and that everything, even tools and anvils, had to be carried from the Stanley Reward (1130 feet below the Mt. Lindsay spur), some of the difficulties of prospecting in the earlier stages of an ore-body such as this will be realised. In May, 1911, the

(112) *Vide* Plate VI.

corded pack-track constructed by the Government to connect with the Stanley Reward track was completed, and pack-horses were able to get in to the mine.

On the recognition of cassiterite as a constituent of the ore (a fact which does not seem to have been recognised in the early stages), a more vigorous developmental policy was inaugurated, and prospecting by means of adits and crosscuts has continued steadily since that time.

It may be well to remark here that this description of the property is very incomplete in itself. The nature of the ore-body, its geological occurrence, mineralogical associations, and mode of origin have been discussed at some length⁽¹¹³⁾ in the chapter on Economic Geology. This should be read in conjunction with the present descriptive section.

The accompanying plan⁽¹¹⁴⁾ will serve to give an idea of the topography of the immediate locality, and the relative positions of the various workings herein described.

At different points drives have been put in—(a) adits along the length of the ore-body, with crosscuts therefrom to expose the width at intervals; (b) crosscuts more or less at right-angles to the ore-body. At intermediate points trenching has been employed, showing the continuity of the formation and its general nature and width.

South-east Adit.—This adit was commenced from a point about 70 feet east of Tulloch Creek, and about 20 feet above the level of that creek. It was driven east on the ore-body a total of 300 feet into the south-eastern spur.

It was commenced on a bearing $92^{\circ} 16'$,⁽¹¹⁵⁾ and driven 72·8 feet through gossan. The nature of this gossan and its probable mode of origin have already been discussed.⁽¹¹⁶⁾ From this point No. 1 north crosscut extends on a bearing of 3° for 35 feet, 31 feet being in gossan.

A band of well-crystallised prismatic quartz of about 18 inches in width, probably with associated cassiterite, occurs at 9 feet from the main adit. At 18 feet a winze was sunk for 25 feet through banded gossan carrying splendid veins of cassiterite. The gossan was rapidly becoming sulphidic in character, and at a depth of a few more feet

⁽¹¹³⁾ *Vide* pp. 65 to 97.

⁽¹¹⁴⁾ Plate VI.

⁽¹¹⁵⁾ Detailed particulars of work done obtained from company's official plan furnished to Chief Inspector of Mines Office. Plan drawn by A. E. O'Brien.

⁽¹¹⁶⁾ *Vide* p. 108, *et. seq.*

would have changed into true sulphide ore. The seams of tin oxide with prismatic crystals of quartz ⁽¹¹⁷⁾ showed no signs of cutting out at the bottom of this winze, which is the deepest point at which the ore-body was cut on the property. Water was encountered in sinking, and work has been discontinued pending the installation of a pump. In the No. 1 north crosscut at 31 feet from the adit there is a sudden change from thoroughly oxidised red gossan to black semi-decomposed pyritic material, with abundant melanterite and some stains of malachite. Decomposing sulphides occur in the face, showing that the full width of the ore-body has not been exposed. Assays show a trace of tin in this material.

Continuing along the main adit on a bearing of $80^{\circ} 6'$ for 28.3 feet, still through gossan with bands of clay varying from white through brown, to red in colour, sometimes carrying magnetite, at 101 feet from the entrance we come to—

No. 2 north crosscut, driven 13.8 feet in a direction $16^{\circ} 42'$ through clay and gossan. In the face the junction between oxidised and decomposing pyritic material is sharply defined, the pyritic material dipping south at 78° .

The main adit now bends a little south, the distance to No. 3 crosscut north and No. 1 south being 72.2 feet on a bearing $104^{\circ} 53'$. The adit is through clays and gossan, and at several points veins of 1 inch to 2 inches of crystallised cassiterite were noticed. The strike of the clays, representing residual bands of country-rock, corresponds with the bearing of the adit along this stretch.

No. 3 north crosscut extends for 27 feet on a bearing $17^{\circ} 49'$ from 173 feet from the approach. Gossan extends for 7 feet, and at this point a rise was put up to the surface, a distance of 62 feet. This was through gossan all the way. A good vein of granular cassiterite about 2 inches in width was met with here. The gossan also carries tin. Along the crosscut from the rise is 10 feet of decomposing pyritic material, with hard bands of unreplaced slate, and some veins with prismatic quartz crystals. The final 10 feet is in true sulphides, banded, with alternating bands of hard slate, carrying garnet and lime silicates, and also fluorite and siderite. The sulphides are pyrite, pyrrhotite, and chalcopyrite, and with them is magnetite. Some hornblende and biotite occur in the gangue.

(117) *Vide* description on page 82.

This zone is very wet. In the pyritic belt abundant crusts of limonite were noticed; and in the semi-oxidised portion melanterite and chalcantite, and in places a little malachite, were common.

Assays of the gossan in this crosscut showed 4.6 per cent. tin oxide, according to figures kindly furnished me by the company.

From the same point in the south-east adit, 173 feet from the approach, No. 1 south crosscut was driven at $193^{\circ} 19'$ for 52.8 feet. For 44 feet this is through oxidised material, consisting essentially of banded white and brownish clays, with narrow bands of true gossan. The limit of the oxidised material is met at 8 feet from the face, where hard slates with fine pyrites make their appearance. The mineral is sometimes partly decomposed. In the face the slate shows many cross fractures and faulting on a very small scale.

This crosscut has evidently been driven through a zone in the ore-body, in which the mineralisation has been comparatively slight. I am informed that assays fail to show the presence of tin in the crosscut.

From the intersection of the No. 3 north and No. 1 south crosscuts the main adit is driven for 53.8 feet on a bearing $111^{\circ} 14'$, and then a further 47.3 feet, bearing $127^{\circ} 47'$ to the intersection of crosscuts No. 4 north and No. 2 south. For 18 feet this section is in gossan and clay bands. At this point a vein of about 2 inches of crystals of translucent brown cassiterite was noted. From this point onwards decomposing sulphides make their appearance, the adit being driven on the well-marked boundary between semi-pyritic and truly-oxidised portions.

At about 50 feet is a short crosscut for about 6 feet south in oxidised material, exposing 5 feet of white clay bounded by gossan. On the north wall of the adit are exposed 13 feet of banded sulphide ore-material, consisting of pyrrhotite-magnetite-hornblende, with slate bands. From this point to the crosscuts north and south are altered slate bands rich in lime-silicate minerals. Garnet, wollastonite, vesuvianite, and crystallised calcite were noticed, sometimes with magnetite and hornblende. The dip of the bands is south at 76° .

No. 2 crosscut south from the south-east adit, 274 feet from the entrance, extends only 28.5 feet on a bearing $204^{\circ} 42'$. This is through oxidised material, mainly gossan, for 20 feet. Then comes an interesting occurrence

of lime-silicates, with a seam of irregular width up to 12 inches, filled with crystals of vesuvianite, and in the face about 1 foot of tough lime-silicate hornstone. This occurrence has been fully described in another place.⁽¹¹⁸⁾ A sample of this vesuvianite vein was sent to the Government Analyst to be assayed for tin. His report was "No tin."

No. 4 north crosscut has been driven for 35 feet, and bears $18^{\circ} 24'$. The gossan extends for 8 feet, the remainder of the crosscut being in pyritic material. This zone is very wet, the walls and roof being encrusted with soft limonite. The pyritic material is essentially of the pyrrhotite-magnetite-hornblende variety, with hard bands of slate carrying pyrite and sometimes garnet, calcite, and probably other lime and magnesia minerals. At one point a band of about 2 feet was seen to carry a good deal of quartz, associated with fluorite, chalcopyrite, and pyrite. Although it was not noticed, it is probable that tin oxide occurs in this band.

The sulphides from this crosscut are said to have assayed 0.4 per cent. of tin oxide.

From its intersection with the two previously described crosscuts the main adit has been driven 26.5 feet on a bearing $118^{\circ} 17'$: this is the furthest extension east of the workings. For 8 feet this portion of the adit is through semi-pyritic slate, a good deal decomposed. The slates show perfect cleavages, and are very friable. The strike here is north 62° west, and dip south at 80° . Then for 5 feet the slates are much crushed and broken; the ground is bad standing, and white kaolin seams were noticed. There appears to be a fault here, striking about north 7° west, although it is not possible to say what the displacement has been, if any.

For the remaining $13\frac{1}{2}$ feet to the face the slates are hard and less disturbed; they carry bands of lime-silicates, and some pyrite. The strike here is still north 62° west, and dip south at about 85° .

Subsequent to the writer's complete examination of the mine, but before he finally left the field, an intermediate crosscut was driven north between Nos. 2 and 3 north crosscuts, at a point 120 feet from the approach. This passed through gossan for 15 feet, when a rise was put up for 30 feet on some high-grade tin ore. From a point about 20 feet above the floor of the main adit, an intermediate level was driven east and west on the course of

(118) *Vide* page 94.

the vein of tin ore. A connection was made with the rise from the No. 3 north crosscut, the tin vein being continuous, and, in addition, the intermediate level was driven west about 40 feet. The manager's report on this work stated:—

“ This drift (intermediate—L.L.W.) produced approximately 20 tons of ore of an average value of 25 per cent. tin oxide, as well as a quantity of oxidised (gossan) ore, of a grade ranging from 5 to 10 per cent. tin oxide.”

The nature of this occurrence has previously been described in this report.⁽¹¹⁹⁾

From the approach to the south-east adit to Tulloch Creek the outcrop of the ore-body has been stripped for part of its width. The south (hanging-wall) side is partly covered by the heap of ore won from the adit, while the stripping has not been continued quite far enough up the hill (north) to expose the full width. Several distinct veins of tin oxide of about 1 inch in width on the surface are noticeable here in the portion available for examination. The ore has the usual banded character, and is semi-pyritic even at the surface. A feature which the writer regards as very favourable for the occurrence of good tin values here is the abundance of fissures filled with prismatic crystals of quartz, some with partially decomposed pyrite. These quartz crystals are held by the writer to have been produced by the same agencies which introduced the cassiterite. Although it does not necessarily follow that cassiterite will be found in all of them, it is almost certain that it will be in some; the occurrence in the winze from the south-east adit, described elsewhere,⁽¹²⁰⁾ will be found to be typical of others.

The No. 1 trench, known also as Cameron's Cut, has been extended only partly across the ore-body on the hanging-wall side of the formation exposed between the south-east adit and Tulloch Creek. In this locality the zone characterised by magnetite is developed on the hanging-wall side, and 44 feet are exposed. The character of the ore in this trench has already been described.⁽¹²¹⁾ The occurrence here of a band of at least 4 feet of chlorite-magnetite-siderite with good tin oxide has also been noted. This band is estimated by the management to contain on an average 4 per cent. metallic tin.

⁽¹¹⁹⁾ *Vide* page 83.

⁽¹²⁰⁾ *Vide* page 82.

⁽¹²¹⁾ *Vide* page 80.

This trench was cut in the early days of exploitation of the ore-body, before its nature was really understood, and although this band carried such good tin values, the cassiterite occurring in fairly coarse as well as some very fine crystals, the search for a metal which is not apparently even represented in the ore (nickel) seems to have caused the only mineral of economic value present to be overlooked. For some time the presence of tin in the ore appears not to have been even suspected, and it seems that it was first recognised in ore from this trench.

The hornblende-pyrrhotite type of ore, described elsewhere, is strikingly well developed in the No. 1 trench.

A little further west, crossing the creek and giving one of the best sections across the ore-body available, is the No. 2 trench, cut by Mr. O'Brien. The mineralised zone here is over 100 feet in width, of the usual banded nature, containing many bands of country-rock, and the ore exposed is all primary, all types—dense magnetite, pyritic magnetite, and pyritic ore—being well represented. Some veins carrying cassiterite have been exposed.

The class of ore met in this trench has been fully described in a previous chapter.⁽¹²²⁾

About $1\frac{1}{2}$ chain north-east from No. 1 trench, on the western bank of Tulloch Creek, the formation was stripped by Mr. T. MacDonald when he discovered the ore-body. On the extreme hangingwall side, as exposed, are bands of dense magnetite, merging towards the footwall side into magnetite-pyrrhotite-pyrite, then into more massive pyrrhotite and pyrite with hornblende and biotite as the most abundant gangue minerals. The ore varies from point to point, as has already been noted. Some bands here are densely pyritic, some bands of 6 to 8 inches having no distinguishable gangue minerals; others, again, appear to be composed almost entirely of biotite, others of hornblende and biotite. Veinlets of green and violet fluorite with chalcopyrite were noticed in places. Further towards the footwall side the mineralisation has been less intense, the "lode-fissures" being more widely spaced, and consequently the altered slate bands becoming more frequent. The ore becomes more truly pyritic, while developed in some of the bands of country-rock garnet and other lime silicates were noticed.

It was from the formation exposed here that the sample which is said to have given returns for gold, antimony, and

(122) *Vide* pp. 71-79.

nickel (¹²³) was taken. A sample from as nearly as possible the same zone was sent by the writer to the Government Analyst, Mr. W. F. Ward, for analysis, who reported:—"No appreciable antimony, nickel, gold, or tin."

Careful examination was made of many specimens of ore from different parts of the formation, and blowpipe tests applied in many cases, but the writer was unable to detect the presence of any antimony or nickel minerals.

It was in part of the ore-body exposed by this stripping, towards the hangingwall side, that the Tulloch adit was commenced, at about 15 feet above creek-level.

It was driven on a bearing 293° 52' for about 20 feet in a band of pyritic ore, but was discontinued owing to the extremely hard, tough nature of the ore. No crosscutting was done, hence the work does not afford much information. The ore consists of bands varying in width from mere stringers to 3 or 4 inches, of pyrite with some pyrrhotite and marcasite, with intervening bands (original country-rock) replaced by biotite, with some hornblende and magnetite, as the more abundant minerals. Siderite was noticed in places, and some rather irregular veins of fluorite with chalcopyrite, and sometimes quartz. Probably cassiterite is present in these veins, though none was noticed. The sulphides from this adit are said to show traces of tin on assay. One fact noted in the examination of Tulloch adit is the presence of fissures cutting across the bands in various directions. Slight slickensides were noticed in some instances. A close examination was made to determine whether there had been any displacement of the mineral bands cut across: in most cases no displacement could be detected, although in a few instances there had been a slight movement. Occasionally a little calcite was noticed in the fissures.

An adit and crosscuts at this level would have afforded valuable information, and would have given a maximum of about 340 feet of backs. Undoubtedly driving in this class of ore is costly, as it is extremely hard and tough. It is questionable whether better progress would not have been made had the adit been driven in the formation a little further to the north.

On the eastern slope of the Mt. Lindsay spur, about 3½ chains west of Tulloch adit, the width of the ore-body has been exposed by a trench about 2 chains in length. The upper (south) end of the trench exposes ironstained gossanous clays, with some bands of decomposing pyritic

(¹²³) *Vide* page 147.

material for about 30 feet. Then follows about 70 feet characterised by abundant magnetite. The zone throughout shows a well-marked banded structure: some bands are pure granular magnetite, others carry pyrite and pyrrhotite, sometimes with hornblende and biotite in the gangue. In some bands pyritic minerals predominate, with subordinate magnetite.

Cutting through the magnetite are irregular seams carrying crystals of quartz, associated with fluorite and chalcopyrite, sometimes with crystals of cassiterite. Calcite is sometimes present in these seams, and siderite was also noticed. In some localities scattered crystals of very fresh arsenopyrite are present. One rather striking specimen showed an irregular lens-shaped fissure up to $1\frac{1}{2}$ inch in width, filled with calcite and quartz, carrying fairly abundant crystals of black cassiterite. At intervals through this dense magnetite zone cross-fractures were noticed, cutting the mineral bands at different angles, with perfect crystals of black cassiterite projecting from either wall.

The lower (northern) 25-foot section of this trench is partly filled in and not available for complete examination, but apparently exposes sulphides of normal type.

About $1\frac{1}{2}$ chain west of this trench, along the line of lode, and at a point about 150 feet above Tulloch Creek, a short crosscut has been driven into the ore-body, called the No. 2 west crosscut. This has been driven for 20 feet on a bearing of 238° , the approach cut being about 30 feet. The overburden exposed here is about 3 feet of clay, which does not appear to carry much tin. In the approach are exposed bands of semi-oxidised slate carrying pyrite, with some narrow bands replaced by pyrite and pyrrhotite with hornblende, and in some cases siderite and calcite. This would appear to be about the edge of the mineralised zone. Some of the slate is very fresh, and shows cross-fractures intersecting at all angles, all filled with pyrite. Some of the bands are thoroughly chloritised.

The crosscut exposes alternate bands of mineralised country-rock and of ore, essentially pyrite and pyrrhotite with hornblende, and sometimes biotite and a little magnetite. In some bands lime-silicates are abundant, and a little chalcopyrite and arsenopyrite were noticed. In the face the ore is typically pyrite and magnetite, with a good deal of biotite, and some siderite and scattered chalcopyrite.

The crosscut seems to have been discontinued on the border of the magnetite zone.

Dense magnetite outcrops on the surface above the crosscut, showing some coarse cassiterite crystals in cross-fissures.

I am informed that a few lenses of ore carrying visible cassiterite were cut in driving this crosscut.

Three chains west of the No. 2 west crosscut, No. 4 trench has been cut across the ore-body. This trench is about 100 feet in length, and has been cut to a depth of 10 feet in places. The ore-body as exposed is completely oxidised in places, and is covered by 2 to 3 feet of yellow-brown clay overburden. At the upper end (south) about 15 feet of weathered slate with signs of pyritic mineral are exposed, followed by a zone of about 40 feet characterised by magnetite, banded as usual, and associated with varying amounts of biotite and pyritic material. Some bands (where evidently the pyritic material was dominant) are now converted to gossan, consisting of hematite and limonite, showing fresh magnetite disseminated through it. In this magnetite zone, several cross-fissures carrying crystals of black cassiterite, associated in one or two cases with prismatic crystals of quartz, were noticed. The northern section of the trench exposes about 45 feet of completely oxidised material, consisting of banded clays and gossan. In several of the true gossan bands (up to 5 feet in width) seams of prismatic quartz crystals were noted. This association was repeatedly noted, and is held to be of significance in the formation of the gossan. This question has been discussed elsewhere.⁽¹²⁴⁾

From the semi-pyritic material occurring in some of the gossan it is likely that true sulphides occur at no great depth.

Still ascending the eastern slope of the Mt. Lindsay spur, about 2 chains west of the No. 4 trench, the No. 1 west crosscut has been driven. This is 1726 feet above sea-level, or about 276 feet above the level of Tulloch Creek, where it intersects the ore-body.

Thus the maximum backs available amount to about 90 feet.

On a bearing of $214^{\circ} 42'$ the No. 1 west crosscut has been driven for 75 feet. For 25 feet it is through gossan, said to assay about $\frac{1}{2}$ per cent. tin oxide. At 37 feet from the entrance very massive magnetite-biotite ore makes its appearance, and continues for about 25 feet. In this

(124) *Id.* page 109.

zone crystallised cassiterite was noticed in irregular nests and pockets in dense magnetite. The next 20 feet discloses gossan with magnetite, representing an oxidised zone of pyritic magnetite. The remaining 5 feet shows bands of clayey gossan. From this point a drive has been put in towards the north-west on a bearing of $299^{\circ} 42'$ for 94 feet. For 60 feet this is through a reddish-yellow clay gossan, representing evidently weathered country-rock, which has been impregnated with mineral to varying extents in different bands. At this point a fault-plane was encountered, apparently with a strike of about north $55\frac{1}{2}^{\circ}$ east, and dip south-east. This occurrence and its effect on the ore-body have been referred to in another part of the report.⁽¹²⁵⁾ The displacement appears to be about 70 feet. From the fault-plane the drive extends for 34 feet through a zone of much-crushed and fractured sulphidic slate, containing abundant scattered pyrite. At 30 feet a dyke of granite-porphry was intersected, striking about east and west, and about 18 inches in width. After passing through this fracture-zone for 34 feet the cross-cut was extended on a bearing of $205^{\circ} 50'$ for 62 feet through similar disturbed country, still carrying a little scattered pyrite. At one point a narrow fissure filled with black tourmaline was intersected. The fault-plane was again met here; it shows slickensides, and there is a "dig" of white clay.

Altering to a bearing of $214^{\circ} 45'$ the drive continues for 30 feet through banded clay gossan similar to that already passed through.

A short drive was put out for 13 feet in broken country, on a bearing $306^{\circ} 24'$, and another at $248^{\circ} 5'$ for 15 feet. This work was being continued at the time of my visit.

The ore-body intersected was of the pyritic magnetite-biotite type, I am informed.⁽¹²⁶⁾

The writer was informed by the management that the magnetite-biotite zone intersected in this crosscut averages $\frac{1}{2}$ per cent. metallic tin. The full width of the ore-body has not yet been exposed in these workings.

On the summit of the spur three more trenches—Nos. 5, 6, and 7—have been cut to expose the ore-body. The ore as disclosed in each of these trenches is similar in character, and similar to that exposed in other parts of the section. A zone of magnetite is exposed about 40 feet in

⁽¹²⁵⁾ *Vide* page 107.

⁽¹²⁶⁾ *Vide* page 107.

width, banded as usual. Gossan also occurs, but judging by the semi-pyritic material noticed at one or two points this is not likely to continue to any great depth.

A little tin is present in the ore exposed in each of these trenches. In No. 6 trench dense magnetite was observed to carry cassiterite in perfectly-formed black crystals. As in other parts of the ore-body already noted, cross fissures were observed carrying coarse cassiterite crystals, sometimes with associated prisms of quartz. About 40 feet in width appears to carry tin here.

In No. 7 trench some fine crystals of tin oxide were noticed in limonite and haematite, sometimes standing out noticeably on weathered surfaces. Veinlets of granular tin oxide of narrow width were also noted here, similar in appearance to that met in the No. 1 rise from No. 3 north crosscut of the south-east adit.

The tin ore occurring here is similar to that which was won from the alluvial on the adjoining section on the western slope of the hill.

In addition to the work already described, an adit has been driven eastwards into the hill from a point about 80 feet inside the western boundary of the section. This has been called the western adit; it is on the western slope of the Mt. Lindsay spur, 143 feet below the summit of the hill. An approach of about 10 feet has been cut, and from the entrance the adit has been driven a total distance of 200 feet on a bearing $105^{\circ} 59'$. From the main adit crosscuts are driven north and south.

For 60 feet from the entrance the adit passes through poorly-banded clays, with a little magnetite and a limited amount of true gossan consisting of limonite and haematite in nodules and well-marked bands. This zone evidently represents a belt of country-rock which has not been very heavily mineralised, but has carried occasional bands of heavy sulphides. Then for 6 feet is gossan banded, and carrying magnetite, followed by 30 feet of yellowish and white clays with occasional nodules and bands of gossan. Four feet of true gossan is exposed, to the collar of crosscuts both north and south, which are driven to prove the width of this gossan.

No. 1 crosscut north extends 22 feet on a bearing $17^{\circ} 35'$. For 13 feet it exposes true gossan, and then 7 feet of clays with a little gossan. The gossan passed through shows prisms of quartz in certain seams.

The No. 1 crosscut south, bearing $196^{\circ} 55'$ has been driven for 50 feet. For 30-feet bands of gossan and reddish clays alternate, sometimes with magnetite, and also

with veins of well-crystallised quartz. This is followed by 6 feet of hard semi-pyritic ore with very abundant magnetite. At 37 feet from the main adit is a fault-plane striking about north 60° east, the slates on either side for a total width of 8 feet being much disturbed and crushed, the strike of the bands being altered and vertical slickensides developed. Magnetite, biotite, and pyrite were noted, but as the zone forms a natural leaching zone and is very wet the pyritic minerals are much decomposed. From this fault-plane to the face 6 feet of banded clays with decomposed pyritic bands strike north 63° west, and dip vertical.

From the No. 1 crosscuts north and south the main adit continues for 35 feet with a bearing $105^{\circ} 59'$ to No. 2 crosscut north. This is entirely through gossan, sometimes with quartz crystals, sometimes showing black pyrolusite crusts in cavities.

No. 2 crosscut north is driven for 36 feet, its bearing being $21^{\circ} 20'$. For 31 feet it opens up gossanous clays, in bands yellow to red in colour, also white, and alternating with some bands of thoroughly decomposed pyritic material. At the end of the crosscut is developed 3 feet 6 inches of lime silicate rock; vesuvianite is particularly well developed in perfect tetragonal prisms up to 10×5 mm. in size. In the face, and not fully exposed, is 18 inches of soft, white, gritty clay.

The main adit continues on the same bearing as before for 65 feet to the face of the main adit, and the No. 2 south crosscut.

From the collar of the No. 2 crosscut north, the ore merges rapidly into banded magnetite, and magnetite-pyrrhotite primary ore. Quartz was again noted here in prisms in massive magnetite, and also in small geodes in the same material. At 156 feet from the entrance is a fracture-zone bearing about north 16° east, which forms a regular channel for soakage water. The pyritic minerals are much decomposed, and the bands considerably contorted, showing that some movement has taken place. For about 20 feet the adit continues, the ore being composed essentially of siderite and pyrite in varying proportions. The siderite forms bands several inches in width at times, and sometimes in small geodes crystals of siderite project in ridges, forming typical cockscomb structure, the projecting crystals being coated by minute crystals of a later period. Prisms of quartz associated with chalcopyrite were noted at one or two points. At 176 feet from the entrance is another cross-fissure striking approximately north and

south, about 5 inches in width, and containing decomposed pyritic material and quartz, with melanterite. This fissure, too, forms a regular water-channel. Beyond this, the adit follows the pyritic-siderite type of ore for another 10 feet. Chalcopyrite and fluorite were noted in irregular veins in places, and in one cross-fissure were quartz prisms up to half an inch across in section.

Beyond this is a much disturbed zone, with what appears to be another fault-plane striking north 49° west. For 6 feet the slates are much shattered.

From this point to the face is pyrite-siderite ore, sometimes with quartz. A band of lime silicate rock, with much garnet and calcite, was noted here. This rock is quite similar to that described from the No. 2 south crosscut in the south-east adit.⁽¹²⁷⁾

Several fissures appear in the face, but are unaccompanied by any appreciable crushing effects. The No. 2 south crosscut has been driven along one of these fissures, which dips at an angle varying at different points from 35° to 50° . This crosscut bears $194^{\circ} 47'$, and has been driven in that direction for 38 feet entirely through banded pyritic ore. As in so many other parts of the formation, there are many slate bands not entirely replaced. The ore is typically pyrite-siderite. Locally quartz, fluorite, and chalcopyrite were noticed in limited quantities, and in some places biotite makes its appearance as a gangue mineral. Lime silicates were noted in some of the residual bands of altered country rock.

It is said that assays prove the presence of tin in the sulphides exposed in this adit, but in small quantities only. Also that for 30 feet in width the gossan exposed assays 1.1 to 1.3 per cent. tin.

In addition to the mining work done, a piece of race-construction work has been carried out. From an intake on Tullock Creek near the intrusive granite-porphry dyke shown on the plan,⁽¹²⁸⁾ a race of about 12 chains in length has been constructed, winding round the south-eastern spur. This should give about 100 feet of pressure at the mine itself, increasing considerably for any point lower down, as the creek falls very rapidly in this locality. Although the grade is flatter lower down, according to aneroid readings taken, the difference in level between the junction of the creek with the Four-mile and the mine is about 1116 feet, or an average drop of about 1 vertical in 7.86 horizontal.

⁽¹²⁷⁾ Vide page 94.

⁽¹²⁸⁾ Vide Plate VI.

An attempt has been made in the preceding pages to describe with some degree of accuracy the Mt. Lindsay ore-body. It is recognised that the description has been somewhat laboured in parts, on account of the detailed descriptions given; but such are deemed by the writer to be necessary to convey a true idea of the real nature of the formation to one who has not seen it. A good deal of detailed matter actually recorded in the field notes has been condensed or omitted, but it is thought that sufficient has been included. This type of deposit has not been fully described from Tasmania previously, hence a complete description of the occurrence may be of value in enabling similar deposits to be recognised in other parts, or possibly even in the same district. We know that this is not the only instance in Tasmania of old Pre-Silurian sediments being invaded by granitic rocks in Devonian time. This, of course, does not necessarily mean that such contact deposits must occur in every instance, or that quite the same type will be represented if they do occur, for other conditions, as, for example, the composition of the magma from point to point, must be taken into consideration. But the association suggests that such deposits may occur under suitable conditions.

Again, a discussion of the structure of the deposit, which it is thought will be of direct value to the company concerned, would not have been intelligible without a detailed and therefore somewhat lengthy description.

The genesis of the ore-body, too, has been discussed, and a theory put forward which it is believed will also be of distinct value in helping to inspire confidence in the deposit, for this theory is substantiated by evidence which would have most likely been overlooked if a detailed study had not been undertaken, but which the writer believes adds strong support to his theory.

It may be well, however, to add even more to what has already been said by summarising some of the conclusions arrived at, and making a few general remarks concerning the future of the property.

With regard to the genesis of the ore-body, the writer believes that two distinct processes must be recognised, the first resulting in the formation of the banded ore-body proper, probably before the solidification of the granite, and the second resulting in the introduction of the tin ore into this ore-body by pneumatolytic agencies active at the final stages of consolidation of the igneous mass. Evidence in support of this opinion has been given. The economic significance of this conclusion is to be particularly

noted. Evidence adduced from mines which have been worked in various parts of the world points to the fact that frequently contact-metamorphic deposits do not live to great depths. In this particular case the *main ore-body* may not be permanent. If the assumption that it was formed before the consolidation of the granite be correct, then, evidently, it cannot continue beyond the contact of the sedimentaries with the granite. The width of the contact-metamorphic belt suggests that the edge of the granite-mass dips at rather a flat angle, and hence the granite may actually be met with in mining operations. But from the mode of origin of the *tin ore* we infer that it will be permanent within the limits of economic mining, that it is quite independent of at least the outer crust of the granite, and that even if the granite contact should be met with in mining, the tin values should continue uninterruptedly into the heart of the granite mass beyond the reach of the deepest mining likely to be carried out.

From the structure of the ore-body it is obvious that there is neither true hanging-wall nor true foot-wall. From a zone of maximum mineralisation, the effects decrease on either hand, the bands of mineral becoming fewer and the bands of country-rock more abundant as we proceed outwards from the zone of maximum impregnation. Hence the width of the ore-body as such is indefinite. The point it is desired to emphasise is that care must be taken in opening up the ore-body by crosscuts to extend these far enough beyond the zone of maximum impregnation to make sure that no payable tin veins are overlooked. There is no well-defined wall, on reaching which it is safe to assume that mineralisation ceases. Tin veins of value may be formed in the outer zones of mineralisation. Hence it may prove false economy to discontinue driving these crosscuts too soon. For example, the writer would suggest that the crosscuts driven north from the south-east adit be in each case extended in that direction. He does not consider it by any means proved that the limits of the tin-bearing zone have been reached. The same remarks apply, though to a less extent, to the crosscuts from the western adit, both north and south.

The writer would here again emphasise a fact which has been repeatedly mentioned in the past, that it is not the duty of the Geological Survey to encroach on the practice of the mining engineer. Hence systematic sampling and assaying, estimation of ore reserves, treatment of ore, and other like questions, cannot be dealt within in detail in such a report as the present one.

Reviewing the property and work done in quite a general way, however, a few features appear to stand out prominently and call for some remark.

The ore-body is one of unusually large size, with a width of at least 80 (and in places 100) feet, and a prospected length of 55 chains; the quantity of ore available is enormous. The question which is of vital importance to the company is, "Is the ore payable?" We have seen that tin is present in both classes of ore, the magnetite type and the pyritic type, with intermediate classes as well. But whether it is distributed through the ore-body in sufficient quantities to pay for extraction is a question for the company to decide. It is hardly to be expected that the full width of ore will prove payable. It is, of course, quite possible that the distribution of the economic mineral through this wide mineralised zone is such that it is of no commercial value. This possibility must be faced. On the other hand, however, there is good reason to believe that in certain zones the metal is sufficiently concentrated to pay well for extraction. Considered from the geological and mineralogical point of view, there is no reason why such payable zones should not exist. This question can only be determined by the company continuing to open up the ore-body and to expose it systematically at different points, so that the mining engineer may be able to thoroughly sample it, and not only determine the values of different zones at a few points, but be able confidently to calculate the tonnage available for treatment.

From the description given of the nature of the ore, the impression may be created that it is exceedingly complex. Mineralogically it must be admitted that the ore is complex; nevertheless, it is unlikely that it will offer any very great difficulties to successful metallurgical treatment. This treatment question must, however, receive the consideration it deserves. There is undoubtedly a fair tonnage of gossan available, containing apparently highly payable tin values. But it is essential to keep in mind the fact that the future of the mine will depend, not on the gossan, but on the primary ore of magnetite and pyritic varieties. Experimental work will be necessary to determine the most suitable method of treatment for the primary ore, and this work should not be delayed too long. The question has been asked the writer, "Is it likely that the body of ore developed on the western side of Tulloch Creek will pay to treat in bulk?" This depends not only on the actual tin content, of course, but its mode of occurrence and cost of extraction. There is a limited

amount of gossan on the western slope opened up by the western adit, but the bulk of the ore is primary, and consequently the metallurgical problem looms large, and cannot be neglected. The tonnage available is large, and the facilities for economic mining are not to be lost sight of. With a maximum of about 370 feet of backs from the level of Tulloch Creek, and a width of, say, 80 feet, if the formation really carries values over its full width, the advantages are obvious. Timber is abundant. The question of power naturally demands consideration. Tulloch Creek, in the vicinity of the mine, can probably not be relied on for more than one sluice-head on the average throughout the year, although it would be advisable to have a systematic record kept of the water available at different periods of the year. Obviously, then, when the question of a permanent plant is under consideration, attention will have to be directed elsewhere. The Four-mile Creek offers certain advantages for a small plant, but it is undoubtedly to the Wilson River that it will be necessary to turn in the future. The average fall at points visited by the writer, according to aneroid readings, would appear to be about 40 feet to the mile. The quantity of water available would be ample at all seasons of the year. The alternative methods suggesting themselves at once are (*a*) the establishment of a power-station on the Wilson River and transmission of power to the treatment plant at the mine; (*b*) the transport of ore to a treatment plant on the Wilson.

It is, however, too early yet to consider the establishment of a permanent plant. The ore-body cannot be regarded as sufficiently developed to warrant the construction of a complete plant capable of dealing with such large tonnages as will be necessary, in order to reduce working costs to a minimum.

The question, then, naturally arises as to whether a small plant should be erected. So often does it happen that as soon as ever a body of oxidised ore is opened up on a property which will pay for treatment, a plant is put up without delay to treat this ore, and all energies concentrated on the extraction and treatment of that which will be likely to return a few dividends to anxious shareholders. Meantime the primary ore which is not quite so amenable to treatment is neglected, although it really constitutes the true factor on which the company depends for ultimate success. When the more accessible and easily-treated oxidised ore is gone, and the problem of treating the more complex primary ore has to be faced in earnest,

the shareholders, elated with the dividends received, become disheartened at the prospect, not only of no further dividends for a time, but of impending calls, rendered necessary by experimental work on the primary ore and then alteration of plant to economically treat the same, and the doom of that company is sealed. The picture is not an imaginary one, and has unfortunately been exemplified in the past history of mining in Tasmania.

Such can never be said of the Mt. Lindsay Company, and it is refreshing to find a company with a body of high-grade ore which could be very cheaply mined (by open-cut methods if desired) and economically treated, resolutely resisting the temptation to be premature, preferring to devote their energies to resolutely opening up and exposing the ore-body for sampling and valuation, with no prospect of immediate returns, since there is no output of tin ore. A policy of careful prospecting is especially to be commended in the case of such a large ore-body. At the same time it is possible to imagine too much caution being used. A small prospecting mill would be extremely useful, not only for treating by degrees some of the free-milling ore available, but for crushing bulk samples of the primary ore from different portions of the ore-body, and so getting a far truer idea of its real value than could possibly be done by sampling and assaying in the ordinary way. For it must be remembered that with narrow seams and lenses and pockets of pure cassiterite, such as have been described as occurring in different parts of the ore-body, accurate sampling is difficult, and unless great care is exercised, assay values of samples taken in the ordinary way are apt to be misleading. However, a small mill cannot be erected merely to act as a sampling machine, although it would render valuable service in that respect. Power is available for such a prospecting plant, especially if water were reused for dressing purposes. On the other hand, with the only transit methods available at the present time, it is realised that the erection of even a small unit would be extremely costly, on account of very high packing charges, a wooden tram being available for about 4 miles only, a corded track remaining to be traversed for the remaining 11 miles. At the same time it must be realised that the mine cannot be regarded as fully developed, and the time seems scarcely ripe for improved means of transport at this stage.

With regard to development work in the immediate future, the ore exposed in the portion of the formation east of Tulloch Creek, known as the south-eastern ore-

body, is of such an encouraging nature as to warrant further exploitation. The development of this body at a greater depth than that already exposed is urgent, that the true nature of the primary ore may be disclosed, for the winze sunk even to 25 feet discloses sulphides. Whether this work is to be carried on from a shaft or from an adit driven from lower down the creek to intersect the pyritic body at a depth is a matter for the company's careful consideration. The oxidised ore is so soft that progress in sinking would be rapid until the sulphides were met, unless hindered by water, and from the experience gained in sinking a winze from the south-east adit, only 25 feet, this trouble is likely to be a very real one. On the other hand, driving in the hard slate country to intersect the lode would be costly. When the initial work was completed, however, it is scarcely necessary to point out the difference in cost of upkeep in the two cases. The continual hauling of water, with the raising of the large amount of ore which would be handled from the shaft, when placed against the extraction of the ore above the same level from an adit, show clearly that first cost alone is not the only consideration which must guide the company in making its decision.

Although a survey will be necessary, the writer is firmly of opinion that an adit of moderate length would expose sufficient backs to make it worth while driving, with the additional advantage of prospecting the mineralised zone on the outskirts of the main ore-body. The large tonnage given by a moderate amount of backs with such a width has already been referred to.

Another matter in connection with the south-eastern ore-body, although already discussed in another part of this report,⁽¹²⁹⁾ may be again briefly referred to here. Although in the true sense of the term no secondary enrichment of the gossan has taken place, yet one ton of the gossan would actually yield more tin than one ton of the original sulphide ore from which it was derived. This is obvious on account of the lower specific gravity of the gossan than the sulphide, owing to the oxidation and removal of the pyritic material, while the actual tin content remains constant. This fact needs to be carefully borne in mind if any attempt be made to estimate the probable value of the pyritic material, using the known value of the oxidised as a guide.

(129) *Vide* page 110.

One other point may be referred to in connection with the same portion of the ore-body. Reference has already been made to the rich veins of tin oxide met in opening up the gossan. These are not formed in the gossan by any process of secondary enrichment; hence it is equally likely that they will be found from time to time in opening up the sulphide body.

A matter of great importance is the thorough sampling of the ore-body as at present opened up, and a complete record of the assay results of such samples to be kept for reference, and to be added to from time to time as development work proceeds. The need for care in such sampling has been touched on. Above all, the sampling should be done systematically, and not in any irregular manner. The writer would suggest that such samples be taken over regular widths of, say, 5 feet. The effect of such a system would be to lessen the risk of unintentional "salting" of samples, by including too much material from the narrow rich seams of cassiterite which occur through the ore-body. Any unusually high result obtained would at once be apparent, and a check sample could be obtained to verify the result or otherwise. It should be remembered, too, that even negative results are of considerable value, and should certainly be recorded, as well as the more favourable results. A complete series of assay results systematically recorded, will be found to be of extreme value, and will largely decide the exact planning of future development work on the primary ore.

In conclusion, the writer is of opinion that the Mt. Lindsay ore-body is one of great promise. Although the company has carried out a good deal of prospecting and development work on the formation under considerable difficulties, still, owing to its great size, it cannot yet be regarded as by any means fully developed or in a fit state for a mature opinion to be given as to its future.

It is hoped that some of the explanations and suggestions offered may be helpful as a guide in planning future work, and that future work will bring the company the success it deserves.

Reference must be made to the possibility of a second ore-body being found on the lease. Brief mention was previously made in the preliminary report published some months ago.

When examining the bed of Tulloch Creek above the Mt. Lindsay ore-body, the writer was one day struck by the presence of shrubs foreign to the slate country with its clay soil, but which had been frequently noticed on the siliceous granite country, the so-called "grass-tree"

and "cutting-grass." An investigation revealed the presence of an intrusive dyke of granite-porphry, whose presence had previously been unsuspected. The approximate position of this is shown on the accompanying plan.⁽¹³⁰⁾ A further examination showed the presence of some dense magnetite in some of the altered slate, and in the thick scrub on the eastern bank of the creek, some 10 chains north of the outcrop of the main ore-body in the creek, some highly pyritic banded material was discovered *in situ*, showing biotite in the groundmass. This locality should certainly be prospected, as it is not unlikely that a parallel ore-body may be discovered, which may or may not carry tin values.

One matter which has proved rather puzzling to some on the field is the alleged absence of any alluvial tin shed from the Mt. Lindsay ore-body. It is contended, and justly, that since the creek has cut through and denuded such a large portion of the ore-body some tin oxide must have been derived from it. The writer is doubtful whether such has been carefully prospected for. Tulloch Creek itself, with its steeply graded rock bottom, offers no encouragement for the lodgment of any quantity of detrital matter, and it is not very surprising that very little alluvial tin has been discovered in this creek. Where it enters Four-mile Creek, however,⁽¹³¹⁾ which is a tributary of the Wilson River, there is an alluvial flat, apparently not of any great extent. This creek does not appear to have been prospected, but it is possible that some of the tin oxide shed from the Mt. Lindsay lode may have found a lodgment under these more favourable conditions. The flat is certainly well worth prospecting.

Another portion of the lease which should also be prospected, is the eastern portion, on the eastern fall of the south-east spur, and near the western boundary of the adjoining section, 5200M.

Magnetite and pyritic material were found on this boundary by the writer.⁽¹³²⁾

(3)—ROSEBERY PROSPECTING COMPANY, NO LIABILITY.

This company holds 318 acres, comprised in the following mineral sections:—5552M, 80 acres; 5553M, 78 acres; 5554M, 80 acres; 5832M, 40 acres; 5847M, 20 acres; and

⁽¹³⁰⁾ Vide Plate VI.

⁽¹³¹⁾ Vide Plate II.

⁽¹³²⁾ Vide description of Section 5200M, page 198.

.5931m, 20 acres—and a water-right, 1250-w, for 10 sluice-heads on a creek flowing into the Wilson River.

On one of these sections, 5552m, two men were employed at the time of my visit, and being informed that no work whatever had been done on any of the others, these were accordingly not visited.

This group of sections is situated to the east of the Wilson River, and between that river and the Huskisson, both tributaries of the Pieman. The position of the sections is shown approximately only⁽¹³³⁾ on the accompanying map; they are not charted, and were only connected with other points in the field by bearings taken by prismatic compass to points whose position had been fixed.

Section 5552m includes a tin-bearing formation known as the Mt. Merton Mine. The mine is situated about 3 miles (in a direct line) north-east of the Pieman River suspension-bridge near the junction of the Wilson and Pieman Rivers, and until recently was reached by a foot-track from Renison Bell, about 10 miles distant, crossing the Pieman River by a cage. Towards the end of 1912 a bridge was built over the Wilson River by the Government, and a corded pack-track constructed for $2\frac{1}{2}$ miles from the bridge eastwards. The bridge referred to crosses the Wilson River a few chains above its junction with the Pieman, and about $\frac{1}{2}$ -mile beyond the Pieman suspension-bridge. At this point the Mt. Merton track branches off from the main track to the Stanley River and Mt. Lindsay.

From the $2\frac{1}{2}$ mile-point on the track, where the cords end, it is about 3 miles to the mine, following a blazed track.

The tin occurs in Silurian sandstones, and a few chains north of their junction with the serpentine and basic Devonian rocks previously described.⁽¹³⁴⁾ The section comprises members of the sedimentary Silurian rocks, slates, sandstones, and probably limestones, described in another part of this report.⁽¹³⁵⁾ Serpentine does not appear in the section, the south-western corner peg being within about 2 chains of the contact. The sandstones and slates are fossiliferous; the strike varies from north 88° east to south 80° east, and dip south at from 55° to 65° . The average strike is about east and west, and dip south at 60° . The sandstones weather to a white sand, the slates to a yellow or brown clay.

⁽¹³³⁾ *Vide* Plate II.

⁽¹³⁴⁾ *Vide* page 18, *et seq.*

⁽¹³⁵⁾ *Vide* page 51, *et seq.*

The sedimentary rocks form a ridge bearing a little north of west, rising to a height of about 750 feet above sea-level, or about 150 feet above the flat in which the exact contact between serpentine and sandstone is hidden. This ridge is dissected by several creeks flowing north, which, however, unite to form a main creek, which bends north-west and flows into the Wilson River. Osmiridium has been found in these creeks, which head in the serpentine country to the south, where there is a well-marked ridge running nearly east and west. North of the sections from the main creek referred to, a fairly high ridge of sedimentaries occurs, with a general trend parallel to those described.

The work done on the section consists of several surface trenches towards the eastern end of the Mt. Merton ridge, an adit driven west from this end of the spur, and two adits driven south-west from the northern slope of the ridge.

Tin was discovered in March, 1911, by Mr. A. D. Merton, and a reward section of 80 acres applied for. On survey it was found that the property was within 10 miles of Renison Bell Tinfield, and consequently not more than 40 acres could be granted as a reward section.

There appear to be two distinct units represented on the property—(a) lode-formation, (b) detrital formation.

(a) *Lode-formation*.—The exact nature of this formation is not quite clear, as little work has been done up to the present. The underground work has been carried on by adits and crosscuts.

No. 1 adit (which would be more correctly termed a crosscut, since it is driven across the formation) has been driven from the northern slope of the spur, from a point about 50 feet below the summit of the hill. It has been driven on a bearing of 225° (south-west) a distance of 184 feet. The sedimentaries here strike north 80° west, and dip south at 55° , so the main drive cuts across them at an angle. The approach is 25 feet in length, through soft Silurian slates, and carrying 2 feet of overburden. The adit is driven through slates and sandstones of quite normal character for 75 feet, where an oxidised zone is met. At this point a drive was put in to the south-east for 45 feet, I am informed. This drive had collapsed at the time of my visit, and was quite inaccessible.

The main adit is now in what is called the "lode-formation," and which is said to carry low values in tin. The adit extends for another 109 feet, but at 115 feet from

the entrance, a drive has been put in for 90 feet on a bearing of 308° . The formation exposed consists of slates and sandstones, but not of the normal variety. The sandstones are hardened and contain abundant cavities of quite irregular shape, and encrusted with black carbonaceous material. The cavities always contain irregular ridges of points of hard sandstone projecting, but with no sign of crystal form, nor are any negative crystals to be recognised. The cavities occur not only at this point, but wherever the formation has been opened up. They are sometimes filled with sand, and sometimes with angular fragments of sandstone, evidently derived from the walls of the cavities as weathering has proceeded. These angular fragments are sometimes cemented into a breccia, although never very massive, iron oxide having evidently played an important part in the cementing. The cavities are sometimes lined, *frequently on the upper surfaces*, with lignite.

The zone is wet, and the sandstones quite black with impregnations of carbonaceous material. Tin is said to be present throughout, in small quantities; pyrites was noticed.

At a point about 5 chains north-west, and lower down the hill, a second crosscut called No. 2 adit was driven on a bearing of 213° for 340 feet. The slates and sandstones here dip south at 65° , and strike north 88° east. The backs available would be about 100 feet. No driving has been done east or west.

For about 140 feet normal sedimentary rocks were encountered, fossiliferous slates and sandstones, blue slates predominating. Then oxidised material was met with. Cavernous white sandstones, containing some carbonaceous matter and seams of lignite of varying width were met. This belt is said to carry a little disseminated tin oxide. Water was noticeable, the seams which carried lignite apparently forming drainage-channels for surface water.

The last 60 feet was driven through hard sandstones and quartzites. In places the sedimentary has been converted to quartzite by introduced siliceous solutions, minute prisms of crystalline quartz being developed on the walls of small fissures. A little disseminated pyrite was noticed, and also some cavities of approximately cubical outline suggesting the oxidation and removal of pyrite crystals.

At one point barely showing above the floor of the drive the cap of what appeared to be an intrusive rock was

noticed. The rock is much decomposed, being soft and thoroughly kaolinised. Particles of fresh quartz are still distinguishable in the material, and although the rock is much too decomposed for exact determination, it appears to represent a quartz-porphry, or perhaps a granite-porphry. The occurrence is significant, and points to a connection with an acidic magma.

In this adit several narrow veins (up to 1 inch in width) carrying galena were noticed, strike and dip corresponding with that of the sedimentaries.

This hard quartzite and sandstone is said to carry tin in small amounts through it, though the softer material is said to be more favourable.

From a point several chains south-east from No. 1 adit, and near the eastern boundary of the section, an adit (No. 3) had been driven for about 100 feet. This was in bad repair, and could not be examined in detail, but the material passed through appeared to be similar to that already described, normal slates and sandstones, and some hard sandstone with abundant irregular cavities containing carbonaceous material, and said to carry fair tin values. This has been driven from the south-western slope of the ridge, where it is cut through by one branch of the creek. The bearing of the adit is 292° . Subsequent reports show that this adit was continued to 160 feet after the writer's visit, and that lignite seams were intersected.

In the approach to this adit a vein of galena of about 1 inch in width was cut, conforming apparently to the strike and dip of the country-rock.

In addition to the underground work referred to, a good deal of surface trenching has been done, seven or eight trenches having been cut at various points along the crown of the ridge, from about 1 to 5 chains in length. Although these trenches disclose a considerable amount of detrital material, no further information regarding the lode-formation was to be gained from them.

With regard to the lode-formation, the information available seems to point to the fact that there is a wide zone probably approaching 100 feet in width which has been subjected to alteration, and which appears to have been slightly mineralised throughout. At no point noticed had mineralisation been intense. Nowhere was tin oxide seen *in situ*, but it would appear to be disseminated through a wide zone, and probably to be associated with a little pyrite. The tin oxide is said to be always grey

to reddish-brown in colour, and always extremely fine. It would consequently be difficult to save in actual working operations.

The association of tin with basic igneous rocks appears at first sight to be rather anomalous, for we are accustomed to associate it with granite and acidic rocks. However, when it is remembered that both the basic and acid rocks of the district are derived from the same parent magma it is not so strange. And if the decomposed igneous dyke-rock referred to above be really a quartz-porphyry, as it appears to be, then the genetic connection of the deposit with the granitic rocks at depth is fairly well established.

The ore (if such it may be called) is really a hardened sandstone. The writer is of opinion that during the final stages of the consolidation of the magma which gave rise both to basic and acid rocks, gaseous solutions were expelled, and finding their way through some minute fissures or planes of weakness gradually deposited their metallic contents. This probably took place subsequent to the consolidation of the basic rocks which have given rise to the serpentine.

There is nothing in the nature of the ore to indicate whether in certain zones the metal will be concentrated, *i.e.*, whether certain zones of enrichment are likely to occur. They may or may not occur. There is some reason to expect, if the assumption made with regard to the mode of origin be correct, that richer veins may be met with in the course of exploratory work. On the other hand, the introduction of cassiterite may have taken place without the formation of any very rich veins of sufficient size to be of economic value. I am given to understand that in prospecting the detrital matter, and alluvial in the creeks, no nuggets or rich specimen pieces have been located which justify the assumption that such rich veins do actually occur in the ore-body.

It is the mining engineer who by careful sampling and assaying can decide the matter as to whether the tin is too widely disseminated throughout the body to be of any economic value.

The development work carried out up to the present time is limited, but appears to have been justified by prospects obtained from alluvial in the creeks, and from the surface detrital matter. If, however, from actual assay values of samples systematically taken by a competent man over the whole ore-body, as already opened up, the com-

pany has not good reason to believe that certain zones are likely to carry payable tin then further prospecting work in the hope of finding enrichments is scarcely to be recommended.

(b) *The Stanniferous Detrital Matter*.—The surface-trenching carried out on the property has already been referred to. Although it gave little real information of value with regard to the lode-formation, it showed that there exists a large body of detrital matter which carries a certain amount of very fine tin oxide, along the Mt. Merton ridge. The depth varies considerably, but seems never to have been systematically determined over the property. The work carried out, however, would seem to indicate that it is from 2 to 10 feet, with a general average of about $4\frac{1}{2}$ feet on the summit, and 2 to 3 feet on the slopes of the spur. This "wash" (as it has been called) is reported to be tin-bearing throughout, and it has been shown to extend well beyond the boundaries of the section.

The formation has been described as a true alluvial drift, in which the tin has been collected and concentrated by water action.

The writer cannot agree with this view. An examination of the material exposed in the various trenches shows that no foreign detrital matter is represented; all fragmental types present are to be seen *in situ* in the workings. While most frequently the material is a white sand with no coherence, where fragments of rock are present they are subangular, and no more rounded than could be accounted for by ordinary weathering agencies. Again, in the undisturbed sections afforded by some of the trenches, the detrital material exhibits no signs of stratification. The solid pieces lie at all angles, and are mixed indiscriminately with finer material and sand. I am informed that there is apparently no concentration of tin values in the lower layers of drift.

The writer is of opinion that the formation is simply the result of the action of atmospheric weathering agencies. Throughout the district, wherever the Silurian rocks are exposed at the surface they yield subangular fragments and non-coherent white sand, if sandstones, or clays if slates are predominant. The writer holds that the sedimentaries have weathered *in situ*, and that little transportation and redistribution of material has occurred. The material from the highest parts must gradually find its way down the slopes, and so a slight concentration is likely to have taken place, the lighter material being car-

ried off first, the heavier remaining in close proximity to its source. The cover of button-grass and other vegetation would reduce this action to a minimum. However, if tin were disseminated through the original rocks, this slight concentration extended over a long period would probably be sufficient to make the tin values of the residue appreciably higher than those of the original rock from which they were derived.

But the point should be emphasised that although the mode of origin is different from that of a true alluvial drift the formation may nevertheless be amenable to the same methods of treatment which would be applied to a body of alluvial wash.

The writer can give no opinion as to whether tin is present in sufficient quantities to pay for such treatment. Much work is necessary before sufficient data are available to enable a definite opinion to be formed. The detrital formation could be systematically prospected by methods usually employed for alluvial, shafts or bores, to determine depth and values. The extremely fine nature of the tin is likely to militate against success.

With regard to power, it seems impracticable to get water on to the property, and storage and pumping would probably have to be resorted to, reusing tail-water.

Inadequate transport facilities would also be a serious drawback if it were decided to get any machinery on the property. The methods of access at the present time have already been referred to.

However, the essentials to be given first consideration would be—

- (a) Careful and systematic prospecting by a competent man to determine extent of detrital formation and its actual tin values.
- (b) Experimental work to determine what proportion of the actual values could be saved, and what would be the best class of plant to effect the maximum recovery.

The theory that the formation is truly a detrital one formed *in situ*, and not by transportation and water-concentration, is likely to mean—

- (a) That the extent of the formation is likely to be large, although the depth will probably be limited.
- (b) That the value of the formation will depend on the (still unknown) extent and value of the underlying lode-formation.

If any further surface prospecting be carried out, it should be remembered that the tin content of the detrital matter is a factor of the underlying lode-formation. If rich local concentrations be found in the former, there will be a high incentive to active prospecting of the lode-formation in that particular locality.

(4)—OTHER WILSON RIVER SECTIONS.

Referring to the other sections taken up in the same locality, and which are shown on the plan accompanying this report, being informed that no work of any kind had been done on them, the writer did not visit them.

These are Sections 5574M, 75 acres, and 5575M, 80 acres, applied for by J. A. Lawler and T. Brosnan, and 5576M, 80 acres, and 5577M, 80 acres, applied for by T. O'Shea and J. Lawler. These sections appear to have been taken up in the hope that payable tin-bearing ground might be proved in the Rosebery Prospecting Company's sections.

I could not hear of any tin values being shown to exist on the sections. However, they are all situated near the junction of the serpentine with the Silurian strata, and conditions therefore, may be considered to be in a general way similar to those on the reward section, and some of the remarks made on the occurrence in that section may be found applicable to the other sections of the group.

(5)—SECTION 4771M, 39 ACRES.

This section is charted in the names of E. G. Roberts and N. Conroy. It adjoins the Mt. Lindsay consolidated lease on the west, being on the western slope of the Mt. Lindsay spur. About half the section (the northern portion) is granite, the remainder being occupied by members of the Pre-Silurian sedimentaries, hardened and altered owing to their proximity to the granite contact. The junction is approximately marked by New's Creek.⁽¹³⁶⁾ A small branch of this creek, heading just below the Mt. Lindsay western adit, has been worked for tin by sluicing with water brought by a short race from New's Creek. The quantity of ground available was small, both in extent and depth, but some good tin was won, mainly in the form of subangular nuggets, many of which showed attached gossan. From an examination of the class of detrital material in the tailings-heap, and the descrip-

(¹³⁶) *Vide* Plates II. and VI.

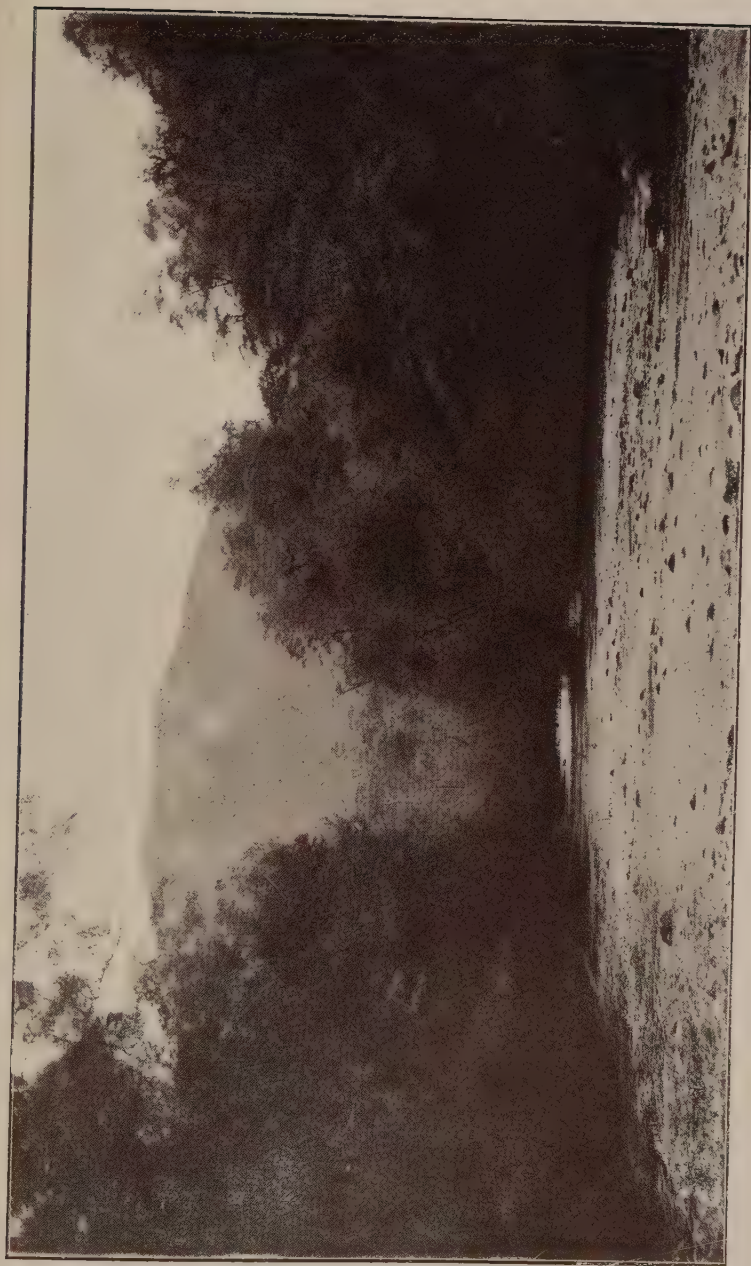


PHOTO. 7—View on Wilson River, showing Parson's Hood Mt. in background, looking West.

[L. L. Waterhouse, Photo.

tion given of the nature of the tin oxide won, the writer is of opinion that it was derived from veins in the Mt. Lindsay ore-body. The small creek referred to here flows along the capping of this formation.

About 5 chains from the western boundary of the section a trench has been cut which exposes a mineralised zone about 80 feet in width. Little has been done beyond removing the overburden for a width of about 4 feet to a depth of 2 to 3 feet. The surface overburden consists mainly of boulders and fragments of granite and abundant quartz-tourmaline.

The ore-body exposed consists of alternate bands of ore and country-rock, varying greatly in width. The general strike appears to be about north 80° west, and dip almost vertical, in places south at 80° to 90° .

The ore as exposed is mainly primary, with a partial oxidation of pyritic minerals in places. On the south side the ore is characterised by the presence of magnetite, much of it very dense granular magnetite, with apparently no sulphides, merging gradually through magnetite-biotite-pyrite, into true pyritic ore. In some bands hornblende is developed, and siderite was noticed. Garnet and other lime silicates are present in some of the residual sheets of country-rock. Fresh arsenopyrite was noticed in places.

The presence of magnetite was noted over a width of about 60 feet.

The pyritic material carries pyrite and pyrrhotite, with hornblende and biotite, and is cut through in different directions by veins carrying quartz, chalcopyrite, and fluorite, up to $1\frac{1}{2}$ inch in width, and in addition, tourmaline was noticed in one or two of the fissures. A little gossan is developed in the northern part of the trench, from the oxidation of some of the pyritic bands.

A more detailed description of the ore-material does not seem called for here, as it is similar in all respects to that exposed on the adjoining Mt. Lindsay lease, and fully described elsewhere. Both magnetite and pyritic zones are typically developed.

No cassiterite was noticed, nor was any information available as to tin values. There is good reason to believe that it is present, as the typical minerals of pneumatolytic origin are developed. There can be little doubt but that this is really a continuation of the Mt. Lindsay ore-body. Between this trench and the Mt. Lindsay boundary the existence of the formation has been proved by an occasional shallow prospecting hole.

The occurrence is of interest and importance, as proving the continuation of the Mt. Lindsay lode-formation to within such a short distance of the granite contact. Unfortunately the actual contact is hidden by dense undergrowth, and no information whatever is obtainable as to whether the formation is continuous within the borders of the granite.

The section is one which deserves more active prospecting than it has received. The alluvial tin won gives good ground for believing that this portion of the Mt. Lindsay ore-body carries veins of tin, which may reward the prospector.

(6)—SECTION 4998M, 20 ACRES.

This section, also held by E. G. Roberts and N. Conroy, adjoins the property previously described. No work has been done. The area includes mainly granite, there being a small development of hardened slates in the extreme south-eastern corner. The potential value of the property lies in the possible continuation of the Mt. Lindsay ore-body into the section. It is doubtful whether it does so, but the surface is covered with almost impenetrable scrub at the present time, which effectually conceals all outcrops.

(7)—SECTION 4772M, 41 ACRES.

The section bearing this number was previously held by P. J. Quinn. It is of irregular shape, partly adjoining the Mt. Lindsay lease on the west, and Conroy and Roberts' section, 4771-M on the south-west.

With the exception of a little clearing of scrub and one or two shallow excavations of small size on the western boundary, no work has been done. The area included consists almost entirely of contact-metamorphic Pre-Silurian sedimentaries, with a small patch of granite in the extreme north-west corner, and another in the south-west corner, just crossing the boundary.

On the western boundary (which also forms the eastern boundary of 4694M) is a contact deposit which deserves brief mention.⁽¹³⁷⁾ Beyond the clearing of a small area by burning the scrub no work has been done on the

(¹³⁷) *Vide* Plates II. and VI.

deposit, which is but 2 or 3 chains from the granite contact, in the altered slates. Much of it is covered by impenetrable scrub, and the few isolated outcrops available for inspection render a careful examination or detailed description impossible.

The striking feature is the banded nature of the deposit, some bands of country-rock being completely replaced by introduced metallic and non-metallic minerals, others only altered and partially replaced. The strike appears to be north 30° west, dip about vertical. The outcrop of the altered zone appears to be about 10 chains in length, and $1\frac{1}{2}$ chain in width, although this includes many bands of country-rock. The general type of alteration is similar to that observed in connection with the Mt. Lindsay ore-body, although the alteration does not seem to have been so intense, there being a very much smaller development of metallic minerals for the same width of altered zone. Magnetite is developed in the western portion of the outcrop, and sulphides on the eastern, as nearly as can be judged.

Garnet is well developed in some of the residual bands of country-rock, and probably other lime silicates are present. No microscopical examination was made. Pyrite and chalcopyrite were noticed, with biotite in the groundmass, and in some specimens siderite was present. Hornblende is well developed, and many loose pieces were noticed of ironstained aggregates of weathering mica. A striking feature, and one worthy of special notice, is the presence of tourmaline, in aggregates of long radiating prismatic crystals up to $2\frac{1}{2}$ inches in length. Many such pieces were noticed amongst the surface detrital matter; in one place a 2-inch vein of quartz-tourmaline was noticed.

On the outskirts of the mineralised zone on the east, and within Section 4772M, is a well-defined dyke of quartz-tourmaline. This varies in texture; one variety having a granitic texture, in which are phenocrysts of glassy quartz and radiating aggregates of tourmaline forming pseudomorphs after felspar, in a groundmass of finely black and green tourmaline and granular quartz. Another variation shows no felspar pseudomorphs, but crystals and scattered irregular aggregates of black and green tourmaline in a quartzose groundmass. This material is sometimes cut through by fissures filled with crystalline black tourmaline. The dyke has a strike of north 35° west. Neither in the dyke nor in the main formation was any cassiterite observed.

The formation appears to be a contact-metamorphic replacement deposit, which has after consolidation been invaded by solutions carrying quartz and tourmaline. Whether tin is present is not certain. Conditions appear to have been favourable for its introduction, and prospecting may prove that it is present in payable quantities.

(8)—SECTION 4694M, 40 ACRES.

* The section is now vacant, but was previously charted in the names of F. J. Baily and P. J. Quinn. It adjoins on the west the section just described, 4772M.

Nearly the whole area of the section is occupied by granite, although there is a small area of Pre-Silurian rocks on the eastern side of the section, the junction being about 3 chains inside the eastern boundary-line, and running approximately parallel with it. Also in the southern portion of the section is a tongue of Pre-Silurians.

The contact-metamorphic replacement deposit described on the preceding section occurs on the eastern boundary-line of this section, and extends a short distance into it. No work has been done on the deposit here.

New's Creek cuts diagonally through the section from north-east to south-west, and its bed has yielded some alluvial tin. The grade of the creek-bed being comparatively flat here, and the shape of the valley allowing it, a body of wash was formed, and this was found to carry payable tin. The small flats on either bank of the creek have been worked for a length of about 10 chains, and an average width of about $\frac{1}{2}$ -chain. The wash appears to have been from 2 to 3 feet in depth, with about 1 foot of overburden. The bottom is granite. The tin won appears to have been largely in the form of rounded and sub-angular nuggets mostly of small size, with a certain amount of finer material. The exact amount won could not be ascertained. The wash is composed largely of rounded quartz-tourmaline boulders, with some representatives of the Pre-Silurians, and gravel and sand derived from the distintegration of the granite.

About 2 chains west of the creek a trench has been cut in rotten granite, exposing a quartz-tourmaline vein about 18 inches in width, striking north 13° west. It is of the usual variety, carrying both black and green tourmaline in aggregates of fine needles. The stains of iron oxide

indicate that pyrites would make its appearance at no great depth. A careful examination failed to reveal the presence of cassiterite.

On the southern boundary of the section (and the northern boundary of 5721m), 12 chains from the south-eastern corner-peg, are some very old workings. A shaft has been sunk on a quartz-tourmaline vein in granite, to perhaps, 20 feet. Being in a state of collapse it could not be inspected, nor was it possible to tell the depth of the shaft. The vein appears to be about $1\frac{1}{2}$ to 2 feet in width. Many pieces scattered round the collar of the shaft were broken and examined. The quartz-tourmaline is quite of the usual variety, but no cassiterite was noticed.

About 1 chain north of this a shallow trench had been cut, but was almost filled with debris, and revealed nothing of interest.

(9)—SECTIONS 5720m, 40 ACRES; AND 5721m,
40 ACRES.

These are adjoining sections, the western boundary of 5720m coinciding with the eastern boundary of 5721m. They also adjoin the previously described section, 4694m, on the south.

Neither section is now held; 5720m was previously charted in the name of E. G. Roberts, 5721m in the names of E. G. Roberts and N. Conroy, and later both were held by T. C. Simpson. Members of the Pre-Silurian series form the bulk of the rocks, although along the northern boundary tongues of granite intrude a distance of 2 or 3 chains in two places. On the boundary dividing the sections, and about 3 chains from its intersection with the northern boundary,⁽¹³⁸⁾ some rich tin ore was won from the alluvial in a small branch of New's Creek, which flows diagonally (north-east) through 5720m. The writer was informed that about $\frac{1}{2}$ -ton of tin oxide was obtained from this one isolated spot, within a radius of about 15 feet. Practically no fine tin was got, all being in the form of specimen pieces, generally in granular masses, angular and sub-angular in form. It is stated that the largest nugget found weighed 75 lb., and that other large pieces were also found. The ground was very shallow alluvial (about

(138) *Vide* Plates II. and VI.

18 inches in depth), and was sluiced with the help of water brought by a small race of but a few yards in length from another small branch creek.

Practically no tin was obtained from lower down the creek, and none from higher up, but in spite of this no work at all seems to have been done to try and locate the source of the deposit. The probable mode of origin of this tin oxide has been discussed elsewhere,⁽¹³⁹⁾ and reasons given for the belief that the tin has been derived from a vein or series of veins quite close at hand, and along the contact of granite with slate, which has been exposed at one or two points in sluicing.

A little prospecting work is certainly warranted here, as there is reason to believe that the source of the tin will be located within a few yards of the spot where the deposit was found.

In the northern portion of 5721M some alluvial tin was won from a small branch of New's Creek, which flows for a time parallel to the northern boundary. Here, too, specimen tin was got. The creek-bed has been stripped for $2\frac{1}{2}$ to 3 chains over a maximum width of $\frac{1}{2}$ -chain. This stripping exposes again the junction of granite and slate, the creek following the junction. This suggests that here again there may be veins along or near this contact, from which the tin was derived.

Some prospecting work has been carried out, but the workings are very old, and appear to be prior to the working of the alluvial.

The shaft sunk on the boundary between this section and the adjoining one on the north, 4694M, has already been referred to when dealing with the latter section. Between this shaft and the creek where the alluvial was found is another very old shaft, now quite collapsed, but apparently sunk on another quartz-tourmaline dyke in the granite.

These sections deserve some further prospecting at the points indicated.

(10)—SECTION 5163M, 40 ACRES.

Section now vacant; previous holder, S. H. Smith. No work was being carried on. About two-thirds of the area is granite, which occupies all the northern portion of the section. The southern part is Pre-Silurian slate, the junction between igneous and sedimentary rocks being

⁽¹³⁹⁾ *Vide* page 117.

approximately marked by New's Creek. No ore-bodies are known to exist, nor could I hear of any tin being won on the section. A fine section is afforded by the Stanley Reward race, which at the New's Creek inlet (water-right 974w for four sluiceheads) exposes the actual contact between granite and slate, showing clearly that the slate is older than the granite, for the latter has hardened and altered it at the contact, and sent out intrusive tongues into the sedimentary rocks.

(11)—SECTIONS 5082M, 40 ACRES; AND 5083M,
40 ACRES.

These sections have a common boundary, and adjoin the previously described Section 5163M on the west and the Stanley Reward Section 133M on the east. Both were charted in the name of C. H. McKendrick.

Granite occupies more than three-quarters of the area, the southern portion of each section comprising Pre-Silurian sedimentaries.

New's Creek flows in a general westerly direction through both sections, closely following the contact between granite and slate in Section 5083. Along this creek small flats occurred at various points, which have been worked for alluvial tin with satisfactory results to small working parties. The amount of ground available was limited, and has now been mostly worked out, although a few small patches remain untouched.

The amount of tin won is not known. It occurred mostly in the form of small to medium-sized rounded nuggets, with some fine cassiterite.

(12)—SECTION 3743M, 74 ACRES; E. WILSON AND
R. G. HALES.

This section adjoins the Stanley Reward section, 133M, on the north. The Stanley River flows through the section from north to south, and is joined about 5 chains from the southern boundary by Castle's Creek from the north-west. The rock throughout is granite. The section includes a strip of alluvial ground along the banks of the Stanley River, and more along Castle's Creek, both tin-bearing. The flats along the river are likely to carry good tin values; the depth of wash is reported to be from 2 to 6 feet, but its extent is very limited, and it is doubtful whether it will prove payable, unless worked in conjunction with that occurring on the Reward section.

The width of the alluvial ground here does not appear to be more than 3 or 4 chains. It is heavily timbered, and its extent has not been clearly determined. The grade of the river is still very flat here, and as in the sections further south, the tailings would need to be elevated.

The ground along Castle's Creek was rather more favourably situated, and has been worked for an average width of about 1 chain for a length of 6 or 7 chains. I understand that some good tin was won here. The bottom is granite of the usual type. The depth of wash appears to have been about 3 feet.

The wash consists almost entirely of well-rounded quartz tourmaline pebbles and boulders of various sizes. Both green and black tourmaline are present in tufts and radiating aggregates, frequently forming perfect pseudomorphs after felspar. In some of these fair tin was noticed, but the large majority of many pieces broken at random from the various tailing heaps showed no tin, even under the magnifying glass.

Mr. Waller,⁽¹⁴⁰⁾ in referring to this section said: "They have stacked 1000 tons of quartz-tourmaline boulders, a considerable proportion of which carry good tin. I took a sample from several of the richer boulders, and submitted it to Mr. W. F. Ward, Government Analyst, for assay. The return was 11·5 per cent. metallic tin. This specimen stone is of all sizes, from boulders 2 feet in diameter down to small pebbles. A small prospect of tin can be got on the shovel by crushing almost any of this quartz-tourmaline stone, but it would be too much to expect it to be all payable. After crushing a large number of pieces of stone, I have come to the conclusion that when no tin is visible the stone will not as a rule carry more than 0·2 per cent. oxide, while a good deal of it contains less than this. When tin can be seen in the stone at all, a good prospect may be expected. It has been suggested that the whole of this wash would pay to put through a battery, and to test this I sampled the stone carefully in bulk. This sample was taken in duplicate, and the results came out identically the same, namely 0·5 per cent. metallic tin, equal to 0·7 per cent. oxide. This result is lower than I expected, but it confirms me in my opinion that most of the tin is contained in the richer stone, in which the ore can be seen by the naked eye. I do not think that it would be advisable to put the whole

⁽¹⁴⁰⁾ "Report on the Prospects of the Stanley River Tinfield," by G. A. Waller (1904), page 9.

of the stone through the battery. The rich stone should be separated from the barren by hand-sorting, while the alluvial was being worked."

No further samples were taken by the writer, but an examination of many pieces over the heaps forced him to the conclusion that the large majority of boulders did not carry visible cassiterite, and that therefore it was very unlikely that it would pay to attempt to treat the heaps in bulk.

There remain still occasional patches of alluvial unworked which carry fair tin, but these are small in extent.

(13)—SECTIONS 4751M, 20 ACRES; AND 4752M,
20 ACRES.

These vacant sections adjoin 3743M, described above, on the north-west. Castle's Creek flows diagonally through them, and along this creek is a continuation of the small alluvial tin-bearing flats described under the preceding section. These have been prospected in places, and the proportion of specimen pieces of ore seems higher; otherwise the wash is of exactly similar character to that described above. The extent of ground likely to prove payable is small.

(14)—SECTION 3953M, 79 ACRES; O. S. DAVIS.

This section adjoins the sections described in the preceding paragraph on the east, and adjoins 3743M on the north. Granite and its facies are the only rock-types represented.

The Stanley River flows through the eastern portion of the section, and there is a small development of alluvial along the banks, of comparatively narrow width, and upon which no work appears to have been done. In the north-western corner of the section, however, some work has been done on a stanniferous quartz-tourmaline vein, locally called "Castle's Lode."

The mineralogy and structural features of this ore-body have been described elsewhere.⁽¹⁴¹⁾ It remains to refer to the actual work done.

The occurrence of rich specimens of tin ore in Castle's Creek led to prospecting in the adjoining spurs, one result of which was the discovery of this ore-body by Mr. W.

⁽¹⁴¹⁾ *Vide* pp. 64, 65, and 108.

Castle in 1903. Aneroid readings show the elevation at the intersection with the northern boundary of the section to be 1280 feet above sea-level, or nearly 600 feet above the Stanley Reward flat.

A good deal of trenching has been done, and an adit comprising over 140 feet of driving, and it is a matter for regret that such efforts were not attended with the success they deserved.

The lowest trench noticed was at a point 270 feet below the northern boundary workings. This trench is in decomposed granite, and does not cut the vein.

A little higher up is another trench which is of doubtful value. Abundant quartz-tourmaline boulders, some of large size, and subangular, are exposed, but are probably not *in situ*. A shaft sunk a few feet was full of water.

About 3 chains up the hill another trench exposes a narrow quartz-tourmaline vein of about 15 inches, bearing apparently north 20° east. The trench and pot-hole sunk are full of water.

A few chains higher up the hill still, what appeared to be the outcrop of a large quartz-tourmaline formation was discovered. This (according to aneroid readings) is 1125 feet above sea-level. The general strike is apparently north 15° east. A little work was done here to expose the ore-body, which is enclosed in decomposing granite, but the supposed outcrop cut out suddenly, and was assumed to be only a huge boulder. Work has been carried on all round it, and apparently a short crosscut has been driven beneath the outcrop, but exposes granite only. The width is irregular, but as much as 12 feet in places. Most of these workings are filled with water.

A trench has been cut about 3 chains north-east from here, still disclosing loose fragments of quartz-tourmaline, while 12 chains up the hill in a direction north 15° east some further work has been done on an outcrop. The strike here appears to be north 50° east, the exposed outcrop being about 50 feet. The width of the body is about 9 feet, and dip vertical. A trench has been cut on either wall of the main vein, to a depth of 6 feet, for 12 feet in length, leaving the main quartz-tourmaline mass standing. This has then been cut through by a trench across its width, sunk to a depth of at least 15 feet. These workings also were filled with water and debris, so the exposed face could not be examined at close quarters. Some rich specimen stone was exposed here, and there was encouragement to continue prospecting, judging by this exposure.

About 110 feet distant in a direction north 30° west from here, and 50 feet lower down the hill, an adit was driven to intersect the ore-body. An approach of 12 feet was cut, and an adit driven for 90 feet on a bearing of $118^{\circ} 30'$ through rotten granite, which shows numerous narrow fissures cutting the granite in various directions. These show slickensides, showing there has been some movement; several narrow quartz-tourmaline veins were also cut. At 76 feet from the entrance the main quartz-tourmaline vein was cut. At 3 feet from the floor of the drive it ended abruptly, being cut off by a fault. The width at this point was 4 feet 6 inches, widening to 7 feet in the roof of the drive. It carries much black tourmaline. In the granite near the ore-body segregations of black tourmaline were noticed. In addition to fissures noted above are some fissured zones, 3 to 4 inches wide, containing crushed feldspars, and consisting of a series of minute fissures, the zones now stained black.

At 73 feet from the entrance a crosscut was extended for 20 feet, bearing 41° through granite. Then on a bearing $289^{\circ} 30'$ a drive was carried for 18 feet; at 6 feet the vein was cut, 6 feet wide at breast height, widening to 9 feet below. The quartz-tourmaline is cut off abruptly at breast height by a fissure, granite appearing above.

From the end of this drive another crosscut was driven 13 feet, bearing $14^{\circ} 30'$, exposing only rotten granite.

These workings give a clue to what was not clear from some of the surface work. The ore-body has been faulted, and in some cases at least the displacement has been considerable.

A few chains north-east from here, and higher up the hill, a trench has been cut for a length of $1\frac{1}{2}$ chain, intersecting the northern boundary of the section. A vein of quartz-tourmaline was cut, width about 15 inches, but no further work was done on it. This point is 1280 feet above sea-level.

It is a matter for great regret that after carrying out this prospecting work under difficulties (for the country is covered with very thick scrub) a vein so broken and disturbed by faulting should have been met. It carries good tin in places, but is probably too much disturbed to pay for working.

(15)—SECTION 4749M, 79 ACRES.

This section adjoins the previously described section, 3953M, on the north. It is well within the granite area.

The trench on the southern boundary has already been described. A little shallow trenching has been done a few chains inside the southern boundary to try and locate "Castle's Vein," but without revealing anything of value. Apparently this is the only work done on the section.

(16)—SECTION 280M, 80 ACRES.

Adjoining Section 4749M on the north-west this section also is entirely in granite. A lode was reported by Mr. G. A. Waller as occurring on the northern boundary of the section, and three attempts were made by the writer to locate this, but in the absence of a guide it was found to be impossible in the almost impenetrable scrub. Aneroid readings on correction showed 2030 feet above sea-level, at a spot which must have been close to the northern boundary, and which has been shown approximately only on the accompanying plan. I am informed that no work at all has been done since Mr. Waller's visit. He⁽¹⁴²⁾ reported: "Another lode has been found on the boundary between the northern section [753M] and Section 280M, 7 chains from the north-east corner of the latter. This lode strikes 30° west of north, and is exposed for a width of 4 feet, though this may not be the full width of the formation. Some of this stone carries a little visible tin, and a sample taken from this yielded 0.9 per cent. metallic tin. It is not possible to judge of the value of this formation till more work is done. The lode is situated right on the top of the spur, and is 1400 feet above the alluvial workings in Castle's Creek. Should it prove a payable lode there are excellent facilities for mining it cheaply to a great depth by means of tunnels."

(17)—SECTION 5006M, 40 ACRES.

This section adjoins the Stanley Reward Tin Mining Company's Section 134M on the east, and was previously held by D. W. Albury and W. F. Maskell, but has now been forfeited. There is a strip of alluvial ground running through the section approximately north-west and south-east a few chains wide. I am informed that no tin has been located. The alluvial is not very promising, being derived from slate country, which occupies the whole area of the section.

⁽¹⁴²⁾ *Op. cit.*, p. 11.

(18)—3985M, 20 ACRES; D. W. ALBURY AND
W. F. MASKELL.

The section adjoins the Stanley Reward Tin Mining Company's Section 133M on the west. It includes about 14 acres of alluvial ground, forming part of the Livingstone Creek flat. This creek flows through the north-eastern corner of the section. Messrs. Albury and Maskell also have a water-right for 4 sluiceheads—3 heads on Livingstone Creek, and 1 head on another creek on the flat. A race and pipe-line of about 30 chains were constructed.

The alluvial ground in this section is stanniferous, so far as prospected, and rests on a granite bottom. The most economical method of working the alluvial would undoubtedly be by amalgamating with the Stanley Reward Company's sections, and working in conjunction with that property.

On the northern part of the eastern boundary the stanniferous contact deposit described in connection with the Stanley Reward Company's property outcrops. This outcrop extends a short distance into the section, and mining operations may prove that the ore-body extends further westwards into the property than the outcrop indicates. A long trench has been cut on the edge of the deposit, and some alluvial tin won at this point, derived largely from the ore-body, the surface soil below the outcrop having been stripped and sluiced.

It is reported that this section was let on tribute, but no work was being carried on at the time of the writer's visit.

(19)—SECTION 4183M, 5 ACRES.

This section was previously held by A. C. Gordon, but is now vacant. It adjoins the previously described section on the north, and Reward Section 133M on the west.

Although the ore-body on the boundary between the two latter sections has been proved to exist within about 2 chains of the south-eastern corner, it does not appear to continue into the section, although no prospecting work has been done. The section is entirely on granite, the south-western corner being on the edge of the alluvial flat.

(20)—SECTION 5086M, 20 ACRES.

The section was previously held by U. Gillham. The main Livingstone Creek flat cuts diagonally through the section, and occupies more than half its area. The creek-

bed has been worked, and some fair tin won, but beyond an occasional prospecting hole no work has been done on the flat.

The north-eastern corner is on granite, the south-western on schists of supposed Pre-Cambrian age.

The alluvial ground seems shallow, and the wash consists of both quartz-tourmaline and schistose rocks, frequently subangular.

(21)—SECTION 4978M, 79 ACRES.

This adjoins the preceding section on the north, while to the east is 3743M, also previously described. It was until recently held by W. Cooper and J. A. Crisp, but is now vacant. The whole of the north-eastern portion of the section includes a massive granite hill, covered with thick scrub. No lodes are known to occur. The south-western corner, however, includes about 30 acres of alluvial bottom-grass flat, through which Livingstone Creek flows. Some tin was won from the creek-bed, and I am informed that a little gold was also got. The derivation of the gold is rather uncertain: it probably is derived from some vein in the schist series, not far from the granite-contact. The tin has been derived partly from the degradation of the granite, partly from stanniferous quartz-tourmaline veins within the borders of the granite, and the writer is inclined to believe from the class of tin described that veins occur at or adjacent to the granite-schist contact, which have supplied part of the "nugget" tin found.

The flat is said to be tin-bearing, but the depth of alluvial is likely to be small, and from general considerations it does not seem to the writer likely that any great concentration of tin ore will have taken place in the flat. The wash consists mainly of flat, angular, and subangular fragments of schist from the slopes of Mt. Livingstone, with a little quartz-tourmaline and other granitic material.

The bottom is likely to be mainly granite, although the granite-schist contact is covered by alluvial material.

(22)—SECTION 4977M, 77 ACRES.

Adjoins the previously described section on the west, and was held by the same men until recently; it is now vacant.

The north-eastern portion includes about 10 acres of alluvial flat, the north-eastern corner being cut through by Livingstone Creek. The creek-bed here has yielded a

little tin. The remarks on the source of the tin and on the nature of the flat, made in connection with 4978M, apply equally to this section. The central, western, and southern parts of the property are in broken, heavily timbered country, occupied by schists and quartzites of probably Pre-Cambrian age.

Crossing the northern boundary of the section is the contact-deposit of iron ore described elsewhere in this report.⁽¹⁴³⁾ So little work has been done on it that the full extent of this formation is not yet known, as it is mostly covered with thick scrub. It forms a bold outcrop, however, and in the northern part of this section, a small prospecting adit has been driven for 85 feet into this outcrop. It passes for 50 feet through firm clay ironstone, then through 10 feet of brownish black, clayey gossan, and finally 25 feet of soft yellowish white clay.

On the outcrop, which here appears to be 120 feet in width, haematite is predominant, sometimes massive and banded, and very often radiating. It merges in places into yellow, earthy limonite, while magnetite sometimes occurs in masses and granular aggregates.

On the south-western edge of the outcrop two or three shallow potholes have been sunk, showing that there is about 2 feet of detrital matter, consisting of fragments of schist, quartzite, schist replaced by quartz-tourmaline, and a few rounded quartz and quartz-tourmaline pebbles. The bottom is schist.

Abundant fragments derived from the outcrop are scattered on the surface in all directions.

On the northern boundary of the section, $3\frac{1}{2}$ chains west of the south-eastern corner-peg of 4958M, a small outcrop of radiating haematite with magnetite is exposed, but no work has been done to open it up at this point, and the width of the outcrop is hidden.

(23)—SECTION 4958M, 79 ACRES.

This section adjoins Section 4977M just described, on the north, and was last held by O. S. Davis. The upper end of the Livingstone Creek alluvial flat extends for about 10 chains into the south-eastern part of the section, which is about 1 mile north-west of the Stanley Reward sections. The alluvial flat has a steeper grade at its upper end, aneroid readings showing an elevation of 900 feet

⁽¹⁴³⁾ *Vide* page 101-104.

above sea-level, or 200 feet above the level of the Stanley River at the Reward workings. The flat is partly covered by very thick scrub at its upper end.

Livingstone Creek flows diagonally through the section, and marks approximately the line of contact between granite and schist country, the former occupying the north-eastern, and the latter the south-western, parts of the section.

The iron ore deposit described as occurring on the northern boundary of 4977M extends also across the southern boundary into this section, where a little work has been done on it. Two or three chains north of the southern boundary of the section a small prospecting tunnel has been driven for 65 feet into the outcrop, which here forms a low ridge rising about 30 feet above the level of the alluvial flat. This drive extends through hard haematite, nearly all showing radiating structure, resembling tourmaline in form. Both fine and coarse radiating forms were noted. There are a few rather earthy bands, some narrow brown clay seams.

A few feet north of this drive is a band characterised by soft white saccharoidal quartz, intersected by black manganiferous veinlets. This has already⁽¹⁴⁴⁾ been described.

A sample was taken from here and sent to Mr. W. F. Ward, Government Analyst, to be assayed for tin. His report was "No tin."

About $3\frac{1}{2}$ chains north-north-west of this drive the outcrop is very bold, the surface having been cleared and stripped over a small area.

The mineralogical composition of this formation, its probable mode of origin, and possibilities have been described elsewhere.⁽¹⁴⁵⁾

(24)—SECTION 3902-93M, 75 ACRES.

Brief reference only need be made to this section; it is not now held. It is situated to the south-west of Section 134M, and partly adjoins that section.

The Stanley River flows through the section.

A little tin was won from a small alluvial flat with the aid of water brought by a race from Cruncher Creek. There can be little doubt but that this tin was derived from some portions of the older Stanley River terraces, remnants

⁽¹⁴⁴⁾ *Vide* page 102.

⁽¹⁴⁵⁾ *Vide* pp. 101-104.

of which are still to be seen on some of the button-grass spurs. These terraces have been cut through and the tin reconcentrated since the period of uplift of the country.

The extent of wash here is not likely to be great.

(25)—SECTIONS 5726M, 80 ACRES; NORTH
PARSON'S HOOD.

Situated on the summit of the spur connecting the Parson's Hood Mountain with the Meredith Range, is a group of sections, shown on the accompanying plans,⁽¹⁴⁶⁾ none of which are now held. The above is the only one on which any work appeared to have been done in the brief time available for inspection. This section was previously charted in the name of H. D. Marsh. The section is very inaccessible, and difficulty was experienced in finding it, owing to the blazed track being quite obliterated in many places by the ravages of bush fires and undergrowth. The section is reached from the Stanley Reward property by following the main track to the Upper Stanley for about $5\frac{1}{2}$ miles, and turning off in the vicinity of Section 3950-93M by an old blazed track, which ascends the steep spur by the most direct route, irrespective of grade. The summit of the spur by this track is about $1\frac{1}{2}$ mile from the turn-off on the river. This turn-off is 810 feet above the Stanley Reward (these heights being determined by corrected aneroid readings), while the summit of the spur is 1620 feet above the same point, or 2310 feet above sea-level.

During the ascent the abundance of quartz-tourmaline was striking; many of the fragments were angular, and had evidently not travelled far from the veins and dykes from which they have been derived.

The summit of the spur is fairly free of timber on the section worked, being covered with button-grass, although a little further north is some almost impenetrable bauera and cutting-grass scrub.

In the short time available, the writer's examination of the section was necessarily somewhat hurried. The summit of the spur is gently rounded in the fashion so typical of weathered granite hills. The work done has been mostly on the eastern fall of the rounded summit, and consists of a good deal of surface trenching and two shafts.

(146) *Vide* Plates II. and V.

A few chains inside the northern boundary a trench about 2 chains in length has been cut, exposing a narrow quartz-tourmaline vein striking about north and south. No tin was visible in the stone.

A few chains south another trench has been cut to a depth of 4 feet 6 inches. Abundant quartz-tourmaline shows in the trench, but does not appear to have been exposed *in situ*. Two chains east of this is a trench 1 chain in length, which again does not yield any very definite information. In the same locality a shaft has been sunk from the top of a small spur. This could not be examined; it was in a state of disrepair, without ladders, and no rope was available. Judging from the heaps at the collar of the shaft, it is probably about 30 feet in depth, and seems to have been sunk in decomposing granite, on a quartz-tourmaline vein, the width of which is probably not more than 18 inches or 2 feet. No tin could be seen in the stone, although many pieces were examined under the magnifying glass.

A short distance south is another trench, several chains in length, which exposes several quartz-tourmaline veins, varying considerably in width.

Twenty-five feet from the upper end of the trench, which is in granite, is a quartz-tourmaline vein 4 inches in width, then 6 inches of granite, another 4-inch vein, 3 feet of granite, and a third quartz-tourmaline vein 5 inches in width. A few feet further east is a quartz-tourmaline vein of 2 feet 6 inches in width, separated by 18 inches of granite from a second 2 feet 6 inch vein of similar character. This appears to be the most important exposure in point of size, and it has been exposed for a few feet in depth. The stone varies somewhat in texture, being at times fine in grain-size, varying to coarse, and consists almost entirely of quartz and green tourmaline; very little black tourmaline was to be seen. The tourmaline is always in aggregates of fine needle-like crystals; frequent stains of iron oxide indicate the presence of pyrites at no great depth. The stone sometimes shows minute fissures, roughly parallel, filled with tourmaline. The strike is from due north and south to north 15° west. Many pieces were carefully examined, but no sign of cassiterite was seen. As a check, however, a sample was broken across the 5 feet of vein-stone exposed (two veins, each 2 feet 6 inches), and submitted to the Government Analyst for assay, who reported "No tin."

About 3 chains south of this trench another shaft has been sunk. No information is available here. The depth is possibly about 30 feet.

Half a chain east is still another trench exposing abundant loose angular pieces of quartz-tourmaline.

The work done on the section shows that much of the quartz-tourmaline scattered on the surface is derived from a series of approximately parallel veins of variable width. The original idea that this was one large lode-formation several chains in width has been disproved. It is a matter for regret that the prospecting work carried out in such an inaccessible locality was not rewarded by some richer find than seems to have been the case.

A large number of pieces of quartz-tourmaline vein-stone were examined from the different exposures made, but in no case was any cassiterite seen. The only sample taken (that from the widest vein exposed) showed no tin on assay. The fact of no tin being observed does not, of course, prove its absence, but it seems to discredit the idea that much rich tin ore exists.

Although the class of stone appears extremely favourable for tin, little hope can be held out that if it is not present near the surface it will be found at a greater depth, for no theory of secondary concentration by leaching from the upper portions of the veins and redepositing at lower levels can be postulated.

(26)—UPPER STANLEY SECTIONS.

No claim is made to an exhaustive examination of these sections having been made. No work was being done at the time of the writer's examination, nor could he learn of any having been done since Mr. Waller's inspection in 1903.

A number of sections (now forfeited) were taken up here along the Stanley River, between 5 and 6 miles north of the Stanley Reward sections, and over 800 feet higher. There is a limited extent of alluvial ground here, the average width for a length of about 20 chains being apparently between 2 and 3 chains. The reported depth of wash is about 2 feet to 2 feet 6 inches, with about an equal thickness of overburden. From information received, Mr. Waller⁽¹⁴⁷⁾ estimated the average value of the wash at about 10 lb. per cubic yard. The grade is very flat, and hence the question of elevating the tailings would need

(147) *Op. cit.*, p. 15.

consideration in the laying out of work. Power could be obtained for a small plant from the upper reaches of the Stanley, which is here, however, a small stream, except in rainy seasons, when the flats would probably be flooded.

A little work was carried out, though little now remains to show the nature and extent of this work. A race appears to have been brought up in one place, although little ground has apparently been worked.

Although tin-bearing ground does exist here, the main drawbacks to successful working appear to be (a) limited quantity available, (b) flat nature of the ground and river-bed, (c) liability to floods, (d) inaccessibility.

The lastnamed is a serious drawback, and has proved one of the chief deterrents to work in this part of the field.

(27)—MINOR'S CREEK ALLUVIAL.

No work was being carried on in this part of the district, although some tin has been won in the past from the bed of the creek. Minor's Creek flows into the Stanley River from Parson's Hood, about $1\frac{1}{2}$ mile above the Stanley Reward sections. In many places the fall of the bed is steep, and it is quite choked by abundant huge granite boulders. Undergrowth is extremely thick, rendering prospecting difficult. Here and there throughout its course for a few yards there are comparatively level patches, and wherever these occur they appear to be extremely rich in tin. In addition to moderately-fine tin, abundant specimen stone occurs, all of stanniferous quartz-tourmaline, or nuggets derived from that variety.

Mr. Waller (¹¹⁸) reported: "A small patch was worked some time ago by a prospector named Minor, and he is said to have obtained six bags of tin from a piece of ground 30 feet in length."

This was in the lower portion of the creek, a few chains above the Stanley River. In the upper part the bed rises steeply, and is choked with boulders, as described above. At a point about 580 feet above the Stanley Reward flat, and apparently in the eastern portion of Section 5005M (the boundary could not be found, and consequently the exact position could not be located), a tributary creek joins Minor's Creek from the north, and here some work has been done.

(¹¹⁸) *Op. cit.*, p. 14.

A spring dolly was erected, and apparently some of the richer specimen stone was crushed by this crude method, and ground-sluiced. The main creek has been worked for a length of 1 chain below the junction, and a width of $\frac{1}{2}$ -chain. Along the branch creek a length of 6 chains has been worked for an average width of about $\frac{1}{2}$ -chain. The boulders consist almost entirely of quartz-tourmaline, many of which were seen to carry tin. From the abundance and angular nature of specimen pieces obtained here the parent lode cannot be far distant, and the writer would unhesitatingly recommend prospecting in this locality.

It is probable that other small patches of alluvial occur at various points along the creek which may pay small parties to work, but in no locality is the extent likely to be large.

The amount of tin won from the creek could not be ascertained.

(28)—MEREDITH RIVER SECTIONS.

On the accompanying general map and mineral chart, a group of sections is shown about $1\frac{1}{2}$ miles west of the Stanley River, on the head of the Meredith River, a tributary of the Pieman.

No reference is made to these sections in the earlier reports on the field, nor could any information be obtained on the field as to whether any work had been done on them. One group of 10-acre sections appears to have been taken up in about 1890 for gold. A few years later a group of 80-acre sections were taken up for "copper, silver, and associated minerals."

No sections are being held here at the present time, but a visit was paid to the locality. The country is covered by button-grass, excepting in the watercourses, where there is generally heavy scrub. The rocks represented are schists, quartzites, and slates, presumably of Pre-Cambrian age. These are cut through in all directions by small veins of white quartz. This is assumed on evidence stated elsewhere in this report to be derived from the Devonian granitic magma, and to belong to the hydro-thermal stage of the intrusion. Such being so, it is possible that gold and other metals may be found.

In the course of his examination of the locality as charted, the writer found no trace of any work whatever having been carried out. The river systems are cutting their way down through the old peneplain, but the accumu-

lations of wash are small, both in extent and depth, and consist of sub-angular to angular fragments of purely local derivation.

(29)—SECTION 5092M, 40 ACRES; E. G. ROBERTS AND N. CONROY.

This section adjoins the Mt. Lindsay consolidated lease on the south and west. The Mt. Lindsay spur occupies most of the section, while Tulloch Creek passes through the north-eastern corner. About 10 chains of this creek is included in the section. No work has been done, nor is any lode-formation known to outcrop on the property. The rocks represented are members of the Pre-Silurian sedimentaries, altered owing to the granite intrusion. The potential value of the property lies in its proximity to the Mt. Lindsay lease. The Mt. Lindsay ore-body outcrops between 2 and 3 chains of the north-eastern corner, and the ore-body appears to be dipping south towards this section at about 75° .

(30)—SECTION 5200M, 40 ACRES.

Previously held by J. Stubbings. This section adjoins the Mt. Lindsay lease on the east, the head of the South-east Creek flowing through its south-western corner. The rocks included in the section are entirely Pre-Silurian contact-metamorphic sediments, so far as known. No work had been done at the time of my visit, although it is quite likely that the Mt. Lindsay ore-body will be found to extend into its south-western corner. On the southern boundary of the section the slate appeared to strike north 64° west, and dip south at about 75° , and carried a little pyrite. Along the western boundary, about 6 chains from the south-western corner, boulders were noticed carrying fairly abundant magnetite, at a point where a small creek flows east into the South-east Creek. A chain further north along the boundary a fragment of decomposing pyritic material, with biotite and chlorite, was found (probably representing pyritic hornblende-biotite lode-material). This scrub is very thick here, and no outcrop was noticed, but it is certain that this material is *in situ* near at hand. It should certainly be prospected for, as the highly stanniferous south-eastern body of the Mt. Lindsay formation may continue into the section.

VIII.—CONCLUSION.

During the course of this report an attempt has been made, not only to investigate the general and economic geology of the Stanley River district, but to apply the results of such an investigation to practical conditions wherever possible. It remains to look briefly at the tinfield as a whole, and to draw a few general conclusions as to its possible future.

A glance at the accompanying general map, and then at the chapter dealing with the mining properties, will suffice to show that many mining sections shown on the plan have not been described in detail. The reasons for this are fairly obvious. Many sections are taken up on every promising mining field which are never worked; they are held for a time because of their speculative possibilities, in the hope that certain properties which are being worked should prove successful, and if this success is not forthcoming, or is too long postponed, the surrounding sections are allowed to lapse. This district is no exception to the general rule. Many sections have been taken up on which no work of any description has been done. If ore-bodies should exist within their boundaries (and doubtless such do exist in some cases) no effort has been made to locate them. As far as possible all sections on which any work at all had been carried out were examined, and in addition, those sections which had any features which seemed to merit special mention. It was thought that the general discussions of the various rock types on the field, their associations and possibilities, taken in conjunction with the position of the sections on the geological map, would be a guide to their possible value, where individual mention of each was not possible.

It is almost inevitable that in a district such as this, where the country is broken and in many places covered with thick undergrowth, and where only two centres were available from which to work, that some of the work done many years ago may have been overlooked. If such has happened it has been quite unintentional.

The Stanley River Tinfield is not to-day the centre of activity which at one time it was confidently expected it would be. There seem to the writer to be several possible explanations of this unfortunate state of affairs. The inaccessibility of the field, and consequent transport difficulties, have been partly to blame. The construction of the Pieman suspension-bridge and the present corded

track certainly improved matters in this respect, but the fact of having to pay £12 to £14 per ton packing charges only, from the nearest railway-station, is still one of the difficulties which confront mining companies and prospectors alike. This, combined with the fact that much of the country is covered with such dense scrub, makes prospecting work, and consequent development of the district, expensive work. To those who are working in spite of this, all credit should be given. Then, again, the field was undoubtedly "boomed" a few years ago, and during the unhealthy excitement of this time a good deal of indiscriminate pegging of sections took place. This matter has been referred to above. The inevitable disappointment which followed gave the field a setback. Then, too, much was expected from one property, and when after a very brief term of seeming prosperity this company was unfortunately obliged to temporarily suspend operations, confidence in the field seemed shaken. The reasons for this temporary failure have been referred to elsewhere in this report. These circumstances have all played a part, I think, in hindering the progress of the field.

It is natural, then, to ask, "What of the future?"

It must be admitted that at present the field is not sufficiently developed to allow a very definite opinion being formed as to what the future holds for the Stanley River Tinfield. The writer would, however, unhesitatingly say that the district is one of great possibilities. He believes that sound reasons have been given in the course of this report for this belief.

Geological conditions are favourable for the development of tin ores in almost any part of the field, although special localities are to be recommended for prospecting. Two facts are of importance: (a) The intrusion of a stanniferous magma into older sedimentary rocks, some at least of which had already been more or less shattered and fractured; (b) consolidation being succeeded by a long cycle of erosion, which removed great thicknesses of overlying rocks, and cut deeply into the igneous rock itself (yet not deeply enough to remove all the igneous and sedimentary rock which formed the most likely repository for tin ores). Owing to this happy combination of circumstances we have developed on the present surface, conditions favourable for the occurrence of both primary and secondary tin ores. The above facts, stated only in a very general way here, but elaborated elsewhere, lead certainly to the conclusion that the field is one which offers inducements to the pro-

spector. The field needs and deserves systematic prospecting; it has been prospected in a general way, but not in detail, except in a few localities. Any of the sedimentary rocks developed on the field may carry tin lodes. The Silurian rocks, east of the Wilson River, are known to carry tin in at least one locality, and are believed to carry gold; other metals, *e.g.*, silver-lead ores, may also be expected. The Pre-Silurian rocks between the Wilson and Stanley Rivers are also favourable for tin, particularly within about a mile of the granite contact. Tin may also be expected in the older schistose (Pre-Cambrian?) rocks in the west of the area. Especially is this series worth while prospecting near the granite contact, for the formation of banded quartz-tourmaline rock at different points (as, for example, on a spur of Mt. Livingstone between 5 and 10 chains west of the Stanley Reward workings) shows that pneumatolytic agencies have been at work, which may well have introduced tin ore with the quartz and tourmaline. Not only the sedimentaries, but perhaps even more particularly the granite itself, deserves more careful prospecting than it has received. Undoubtedly much of the specimen tin in the Stanley River and its various tributary creeks is derived from stanniferous quartz-tourmaline veins in the granite itself. Very few of these have been located, but there can be no doubt whatever but that many others await discovery. With regard to alluvial, the flat on the Four-mile Creek, at its junction with Tulloch Creek, is worth trying, while from its position the extensive Harman River Flat seems particularly favourable. It seems likely that tin will be found here, and possibly osmiridium as well. The writer could not hear of this flat being prospected.

With regard to the future of the field, much interest attaches to the operations of the two companies at work. In each case the outlook is hopeful, and it is to be hoped that success will attend the efforts being put forth, not only for the sake of the companies concerned, but also for the sake of the whole field.

Particular problems facing each company have been mentioned in dealing with the properties.

Apart from these two mines, the future of the field is in the hands of the prospector.

It is unlikely that the extent of the mining field will be confined to the area mapped. The search for osmiridium will employ men further to the south and east, and will probably lead to discoveries of value—tin, gold, or silver—

lead—in the Silurians. It is likely, too, that the country to the north-east will yield tin, and perhaps gold or silver-lead. The country extending towards Mt. Ramsay appears to be especially favourable, and most likely minerals of value will be found there. To the north, too, it is possible that further finds of tin may be made.

The number of men employed in mining at the time of the writer's visit to the field was 16. Of these, eight were employed at lode tin mining, six at alluvial tin, and two at osmiridium (alluvial). At the time of writing, the number winning osmiridium has considerably increased. It is reported that 20 men are now employed searching for osmiridium. With the exceptionally high price ruling for that metal it is little wonder that more are being attracted.

An attempt was made to find out what the output of tin had been from the field, but few figures were available. The amount to the time of the writer's visit would probably be about 45 tons of tin oxide.

With regard to the possibilities of the district other than mining, there are clumps of pines at various points along the Stanley and Wilson Rivers, though not in any great abundance.

On the Wilson, too, several large clumps of magnificent gum and blackwood were noticed. The majority of the timbered country is open myrtle forest, though there is very thick undergrowth in places.

A portion of the area between the Wilson and Stanley Rivers, comprising some of the southern foothills of the Parson's Hood Mountain, appears very suitable for grazing if cleared. It is well watered, undulating country, with a good depth of clay soil.

The general map has been made as complete as possible, but although all care has been used, it is still only a sketch-map. The topography is, it is believed, approximately correct, but it is qualitative, and not quantitative. With the small amount of information collected true contour lines could not be attempted. The heights given are merely aneroid readings, check readings being taken wherever possible, and heights corrected for temperature and daily variation. No bench mark was available on the field, the height of the Mt. Lindsay Mine (manager's residence) being fixed by readings checked several times between Renison Bell and the mine, other heights being based on this.

In the preparation of this bulletin the writer has consulted the various publications of the Geological Survey in addition to works acknowledged in the text, but especially from Mr. Ward's bulletin, "The Tinfield of North Dundas" (Geological Survey Bulletin No. 6, 1909), have I received invaluable help in the elucidation of some of the problems of the Stanley River Tinfield.

The Mt. Lindsay and Stanley Reward Companies placed camps at my disposal, while carrying out field-work. I hereby wish to tender thanks for this hospitality. I am grateful to Messrs. D. W. Albury, E. F. Cash, J. O'Meara, and A. D. Merton for information and assistance.

Above all, I desire to thank Mr. A. E. O'Brien, manager of the Mt. Lindsay Mine, for his invaluable help on many occasions. Without his assistance I could not have visited some of the properties which were remote from field-base and very difficult of access.

L. LAWRY WATERHOUSE, B.E.

Assistant Government Geologist.

Launceston, 20th November, 1913.

APPENDIX I.

REPORT OF STATE MINING ENGINEER ON STANLEY RIVER POWER SCHEME.

State Mining Engineer's Office,
Zeehan, Tasmania,
27th February, 1913.

Progress Report.

The exploratory work has been carried out on this property during the past month, and the position is that by damming the Stanley River at a certain point and raising the water-level about 12 feet, the waters of the Stanley River can be turned into the Wilson River. The valley of the Wilson is cut down lower than that of the Stanley, so that a fall of about 400 feet, as shown by aneroid readings, could be secured with about 4 miles of race.

The flow of water is being measured in the Stanley River, and so far the minimum flow has been 16 Tasmanian heads of 24 cubic feet per minute. This was in dry weather, and in case of any fall of rain the flow increases very rapidly.

With 16 heads falling 400 feet the effective horse-power is over 208.

The Stanley River catchment comprises an area of about 18 square miles. With a rainfall of 108 inches this would give a continuous flow of 353 heads of water. Hence, if storage could be provided, from 100 to 200 head of regular flow could be relied on.

Compass survey and contour lines show that the water can be held back at the Stanley Reward Mine to cover over 100 acres by a dam 50 feet high. By making the dam 60 feet high a continuous supply of over 100 heads could, I believe, be relied on for the whole year, giving over 1200 effective horsepower.

The difficulty is that the water would flood the property of the Stanley Reward Company. The company has not been very successful, and has now let its property on tribute. It may, however, place a considerable value on it if it were needed for the purpose of this scheme.

Without close investigation I believe the cost of the undertaking would be about £30,000. The annual cost per horsepower on the West Coast is over £30 per annum, so that a very large saving could be effected by a scheme of this nature, after every allowance for costs of interest and working.

The work done shows that this scheme is fully deserving of close investigation, and may be a means of supplying cheap power to one of the most promising centres on the West Coast. There is, however, the difficulty with the holders of the leases on the ground, and I would suggest that an examination be now made of the Lake Rolleston district. If the results here are better or equally good, then it can be placed before the Stanley River scheme; if not, the Stanley River can be more closely examined.

It will be understood that all figures and measurements given above require verification.

HARTWELL CONDER,
State Mining Engineer.

APPENDIX II.

EXPLANATION OF PHOTOGRAPHS.

PHOTO. 1.—Panoramic View from the Summit of Mt. Livingstone of Portion of the Stanley River Tinfeld. (L. L. Waterhouse photo.)

The photo. gives an idea of the rugged nature of the central portion of the tinfeld.

A is north, Z south, D east.

AA. Series of granite peaks and ridges forming Meredith Range.

B. Distant peak is Mt. Ramsay.

C. Position of mining section, 5726M, described in text, North Parson's Hood.

CX. North Parson's Hood Spur: east of Stanley River.

DEF. Parson's Hood Mountain—average height of plateau 2800 feet, F being highest point, about 2850 feet above sea-level.

D is granite.

E. Junction of granite and Pre-Silurian slate series.

F. Pre-Silurian slate.

EWNNR is approximate line of junction of granite and slate.

G. Mining section, 280M (granite), described in text: west of Stanley River.

H. Position of Castle's Lode described in text.

I. Distant peak: Mt. Black.

J. Distant peak: Mt. Murchison.

K. Distant peak: Mt. Read.

O. Distant peak: Moore's Pimple.

P. Distant peak: Mt. Dundas.

Z. Distant peak: Mt. Zeehan.

L. Mt. Lindsay spur. The Mt. Lindsay ore-body outcrops on both the eastern and western slopes of this spur.

NN. New's Creek: marks contact of granite and slate.

M. Part of Stanley Reward race.

Y. Position of penstock: head of pipe-line, Stanley Reward race.

S. Stanley Reward workings.

ST. Livingstone Creek alluvial flat, which is stanniferous.

VVVV. Stanley River Valley.

R. Four-mile Creek.

QQ. Button-grass ridge: Pre-Cambrian schists, quartzites, and slates.

PHOTO. 2.—Boulders of Quartz-tourmaline from Stanley River. (L. L. Waterhouse photo.)

The dark crystals consist of aggregates of fine needle-like crystals of tourmaline (generally green) replacing the feldspars of the original granite. The form of the feldspars is retained, the pseudomorphs of tourmaline after feldspar being well shown in the photograph. Sometimes cassiterite is present with the tourmaline. The white groundmass is quartz. Scale of inches is shown.

PHOTO. 3.—View of Pre-Cambrian Schist Country West of Stanley Reward. (L. L. Waterhouse photo.)

Taken from same spot as Photo. 5, but looking south-west. Peaks in background are Z = Mt. Zeehan, B = Mt. Agnew, with Heemskirk Range to the right. SSS is the course of the Stanley River. CCC is Cruncher Creek shown on Plate II. A is part of the Button-grass Ridge. D is the observation-peg shown on Plate II. The white appearance of the ridges (which are thinly covered with button-grass) is due to the white quartz shed from vein-lets cutting through the schists in all directions, as described in text.

PHOTO. 4.—Radiating Haematite, probably Pseudomorphous after Tourmaline, from Mining Section 4958M. (L. L. Waterhouse photo.)

The specimens illustrate the description given in the text of the radiating haematite, with a little magnetite, from the contact deposit on the boundary between Sections 4958M and 4977M, at the head of the Livingstone Creek alluvial flat, Stanley River. Scale of inches is shown.

PHOTO. 5.—Panoramic View of Stanley Reward Alluvial Tin Mine and Environs. (L.L. Waterhouse photo.)

S. Stanley Reward workings.

A. Penstock, end of Stanley Reward race.

AB. Pipe-line.

C. Manager's residence.

TTT. Livingstone Creek alluvial button-grass flat, stanniferous.

VVV shows course of Stanley River.

M is portion of Stanley Reward race.

DEF is Parson's Hood Mountain.

DE is Devonian granite, EF is Pre-Silurian slate, &c.

NN shows course of New's Creek.

EWNNBRR shows approximate junction of Pre-Silurian series with Devonian granite and with Pre-Cambrian schist.

RR is Four-mile Creek.

QQ is button-grass ridge, of Pre-Cambrian schists, quartzites, and slates.

G is approximately position of bar of hard slate in the bed of the Stanley.

L is Mt. Lindsay Spur and approximate position of the outcrop of the ore-body. The main workings are on the opposite (eastern) slope.

J is the distant peak of Mt. Murchison.

K is the distant peak of Mt. Read.

O is Moore's Pimple.

H represents granite boulders.

PHOTO. 6.—Portion of Mt. Lindsay Mine.

The photo. is taken from the mouth of Tulloch adit, looking in a direction about south-east. It shows part of the south-eastern ore-body described in the text.

A is the mouth of the south-east adit, OOO representing ore mined from that adit. The ore-body outcrops at B, but the outcrop is mostly covered by heaps of ore.

T is Tulloch Creek.

Blacksmith's shop and manager's residence on western slope of south-east spur, in the background.

PHOTO. 7.—View on the Wilson River, showing Parson's Hood Mountain in the background: looking about west. (L. L. Waterhouse photo.)

The photo. is taken at a bend in the river, about a quarter of a mile above its junction with the Harman River. The river was fairly low at the time the photo. was taken. It shows the dense scrub prevailing in this part of the district. Parson's Hood is the mountain in the background. Silurian strata on the right of the picture, alluvial on the left, with basic rocks of Devonian age.

GEOLOGICAL SURVEY OF TASMANIA.

LIST OF PUBLICATIONS.

BULLETINS.

- No. 1.—The Mangana Goldfield, by W. H. Twelvetrees 1907
- No. 2.—The Mathinna Goldfield, Part III., by
W. H. Twelvetrees 1907
- No. 3.—The Mt. Farrell Mining Field, by L. Keith
Ward, B.A., B.E. 1908
- No. 4.—The Lisle Goldfield, by W. H. Twelvetrees 1908
- No. 5.—Gunn's Plains, Alma, and other Mining
Fields, North-West Coast, by W. H.
Twelvetrees 1909
- No. 6.—The Tinfeld of North Dundas, by L. Keith
Ward, B.A., B.E. 1909
- No. 7.—Geological Examination of the Zeehan
Field, Preliminary Statement, by W. H.
Twelvetrees and L. Keith Ward, B.A.,
B.E. 1909
- No. 8.—The Ore-bodies of the Zeehan Field, by
W. H. Twelvetrees and L. Keith Ward,
B.A., B.E. 1910
- No. 9.—The Scamander Mineral District, by W.
H. Twelvetrees 1911
- No. 10.—The Mt. Balfour Mining Field, by L.
Keith Ward, B.A., B.E. 1911
- No. 11.—The Tasmanite Shale Fields of the Mer-
sey District, by W. H. Twelvetrees..... 1911
- No. 12.—The X River Tinfeld, by L. Keith Ward,
B.A., B.E. 1911
- No. 13.—The Preolenna Coalfield and the Geology
of the Wynyard District, by Loftus
Hills, M.Sc. 1913
- No. 14.—The Middlesex and Mt. Claude Mining
Field, by W. H. Twelvetrees 1913
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Waterhouse, B.E. 1914

- No. 16.—The Jukes-Darwin Mining Field, by
Loftus Hills, M.Sc. 1914
- No. 17.—The Bald Hill Osmiridium Field, by
W. H. Twelvetrees 1914

REPORTS.

- No. 1.—Preliminary Geological Report upon the
Mt. Balfour Mining Field, by L. Keith
Ward, B.A., B.E. 1910
- No. 2.—The Silver-lead Lodes of the Waratah
District, by L. Keith Ward, B.A., B.E. 1911

RECORD.

- No. 1.—Marine Fossils from the Tasmanite Spore-
beds of the Mersey River, by W. S.
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